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RICE (*ORYZA SATIVA*) GENOTYPES WITH MULTIPLE PEST RESISTANCE

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Seven new rice breeding lines out of 58 were found resistant/moderately resistant to major pests viz., *Nilaparvata lugens*, *Orseolia oryzae* and *Xanthomonas campestris*. Among these lines, R710-3-37-1-1-1 is resistant to all these three major pests and also possesses desirable grain and plant characters. **Ruchi**, a popular variety of this area is used as one of the donors in all seven crosses. Variety IET 6286 showed moderate resistance to Bacterial leaf blight disease (BLB) and brown planthopper (BPH) insect, is resistant to rice gall midge also. This genetic multiple pest resistant material is of great value in formulating the IPM programme for this region.

Key words : Rice, breeding lines, multiple pest resistance, grain characters

Rice crop is very rich in harbouring various insect pests. In formulating the IPM programme for this area, priority always be paid to such a variety which is resistant to Brown planthoppers (*Nilaparvata lugens* Stal), Gall midge (*Orseolia oryzae* WM.) and Bacterial leaf blight disease (*Xanthomonas campestris* pv. *oryzae*). At present it is very difficult to select a variety resistant to these three pests. Variety selected for gall midge resistance often suffers from Brown planthopper attack. Chemical control measures offered against these pests are loosing ground for many reasons. Moreover, emergence of insect biotypes limits the use of resistant varieties employed against single pest. After few years of cultivation, there is likelihood of break down of resistance in these varieties. To overcome this situation, improved new varieties with greater genetic diversity must be introduced in agro-ecosystem. Recently gall midge biotype 5 is identified in Mancompu at Kerala, India (Nair and Ambika, 1994). Similarly Raipur BPH population is more virulent than Pattambi and IRRI, Philippines (Pophaly and Rana, 1994).

MATERIALS AND METHODS

Experiment was conducted during monsoon season (rainy season) of 1993 to 1995 in field conditions for evaluating new breeding lines against gall midge (*Orseolia oryzae* wood mason) and Bacterial leaf blight (*Xanthomonas campestris*

pv. oryzae) disease. Whereas in glasshouse conditions, these lines were tested against BPH insect *Nilaparvata lugens* (Stal), by adopting the technique described by Kalode *et al.* (1975), Pathak and Heinirichs (1982) and Naito (1964).

In field, 30 day old seedlings of test lines were transplanted in two rows of 2 m length at spacing of 15 × 20 cm with TN1, susceptible and ptb-33, resistant check. At maximum tillering stage, all plants were inoculated with *Xanthomonas campestris* pv. oryzae by clip inoculation methods of Kauffman *et al.* (1973). Recommended agronomic practices were followed to raise the crop. Observations on gall midge were recorded from all hills at 50 days after transplanting when gall midge incidence was at peak. Likewise, BLB inoculated plants were observed for disease symptoms at maximum disease pressure and average plant damage score is presented in Table 1. At harvest, the grains were collected for resowing in next rainy season. Grain and plant characters were also recorded.

RESULTS AND DISCUSSION

In a plea to fight with major insect pests viz., Brown planthopper, Gall midge and Bacterial leaf blight, a single variety generally does not meet all the requirements, both resistance to major pests and desirable agronomic characters. But in the present studies, efforts were diverted to hunt for such varieties which could attain all these requirements.

Out of 58 breeding lines, seven lines of F₈ generation were found promising with respect to pest resistance and agronomic characters. Except IET 6286, pure line, all 7 breeding lines were derived from popular variety **Ruchi** which is resistant to Gall midge and moderately resistant to Bacterial leaf blight disease, and is being widely cultivated in this region and developed basically at Raipur. Variety IR 64 is resistant to Raipur BPH insect population (Pophaly *et al.*, 1994). RM₁ (Raipur mutant) variety used as a donor, is resistant to Bacterial leaf blight disease but susceptible to Gall midge population. IR 19661-23-3-2 and IR 27325-111-2-1 donors are gall midge susceptible but resistant to BLB disease which were used as a BLB resistant donors.

All the 7 breeding lines are resistant to Raipur Gall midge population. For Brown planthopper, two varieties viz. R712-1-65-1-1 and R710-37-1-1-1 are resistant. BPH insect feeding on these two varieties was very less (15 and 26 mm²/ 24 h) in comparison to TN1 susceptible check variety (160 mm²/24 h) and other breeding lines; indicating presence of feeding deterrent or antifeedant chemicals. Consequently, these lines also exhibited the highest probing marks (35 and 33/seedling) as compared to other test lines and TN1 susceptible check (18/seedlings). This speculates the presence of inbuilt genetic resistance to BPH insect in these lines. Insect tried often and often to suck the sap from

Table 1. Reaction of rice breeding lines against BPH, Gallmidge and BLB

S. No.	Breeding lines	Parentage	BPH		Gallmidge (1993-95) ⁴		BLB (1993-95)		Duration (days)	Hull colour	Kernal colour	Grain dimension	Plant type	Plant colour
			Rating	Av. ² feed. in 24 hours	Av. ³ Probing marks/seedling	score	rating	Test wt. (gm) 1000 seed						
1.	R 712-1-65-1-1	Ruchi × IR19661-23-3-2	1.0 R	15.0	35.0	0	R	3	MR	33	125	Light golden	SD	green
2.	R 710-3-37-1-1-1	Ruchi × IR 27325-111-2-1	2.58 R	26.0	33.0	0	R	1	R	31	125	Light golden	SD	Green
3.	IET 6286	-	3.20 MR	-	30.0	0	R	3	MR	23	155	Deep golden furrows	T	Green
4.	R 746-2-34-1-2-1	IR 64 × Ruchi	3.31 MR	-	20.0	0	R	1	R	24	125	Straw	SD	Green
5.	R 714-2-9-3-2-2	RM1 × Ruchi	3.87 MR	99.0	22.0	0	R	I	R	28	125	Straw	SD	Purple
6.	R 714-1-19-1-5-1	RM1 × Ruchi	3.94 MR	-	24.0	0	R	1	R	27	125	Straw	SD	Purple
7.	R 720-1-91-2-1-1	Ruchi × RM1	4.15 MR	-	17.0	0	R	1	R	26	130	Straw	SD	Purple

(Cont. on next page)

S. No.	Breeding lines	Parentage	BPH		Gallmige (1993-95) ⁴			BLB (1993-95)		Duration (days)	Hull colour	Kernal colour	Grain dimension	Plant type	Plant colour	
			Plant ¹ damage score	Rating	Av. ² feed. mm ² / in 24 hours	Av. ³ Probing marks/ seedling	score	rating	Test wt. (gm) 1000 seed							
8.	R 714-3-103 -1-3-2	RM1 × Ruchi	4.30	MR	57.0	25.0	0	R	1	R	31	128	Light golden	White LS	ST	Purple ring in green plant
9.	TN1 (S. check)	-	9.0	S	160.0	18.0	9	S	9	S	23	120	Straw	White MS	D	Green
10.	PTB-33 (R. check for BPH & BLB)	-	1.08	R	10.0	42.0	9	S	1	R	18	185	Straw	White LS	T	Green

R = Resistant, MR = Moderately resistant, S = Susceptible, 1 = Data based on 4-7 replication, 2 = Data based on 16-22, 3 = Average based on 5-6 seedlings, 4 = Data based on 120 plants, LS = Long slender, MS = Medium slender, SD = Semi dwarf, T = Tall, D = Dwarf

these lines, but could not meet the proper nutritional requirements, thereby making more probing marks.

The only variety R710-2-1-1 is resistant to gall midge, Bacterial leaf blight disease and BPH and possesses all desirable agronomic characters. It's kernal colour is white, grains are long slender and plant type is semidwarf, moreover, hull colour is light golden and matures in 125 days. Thousand seed weight is 31 g.

Five breeding lines serial No. 4, 5, 6, 7 and 8 are moderately resistant to BPH but resistant to gallmidge and IET-6286 is moderately resistant to BLB.

These breeding lines are under yield trials and awaiting nomenclature.

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RESISTANCE OF SOME INDIAN TRADITIONAL RICE VARIETIES TO THE PHILIPPINES ISOLATE OF RICE TUNGRO DISEASE AND ITS VECTOR, THE GREEN LEAF HOPPER

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Abstract : The Indian traditional rice varieties Jonwphool, Malsundri and Tulsidas showed resistance and Basmata, Bedubhajana, Mundadhan and Sonakathi showed moderately resistance reaction in India as well as in Philippines. Resistance/moderately resistance reaction of Jonwphool and Bedubhajana is indicative of the resistance of these varieties to green leaf hopper.

INTRODUCTION

Rice Tungro Disease (RTD) which is the most important disease for south and south east Asia, transmitted through green leaf hopper (*Nephotettix virescens*), was first observed in the Philippines at IRRI farm in 1963 (Rivera and Ou, 1965). This disease caused by a complex of two viruses, rice tungro spherical virus (RTSV) and rice tungro bacilliform virus (RTBV) shows stunting and yellowing of the leaves and plant. The RTSV transmitted by rice green leaf hopper (GLH) induces a few symptoms but RTBV is not transmitted by leaf hopper and causes severe symptoms of the disease on its own (Cabauatan and Hibino, 1985).

Most of the resistance to RTD is short lived. Resistance to leaf hopper vector generally breaks down after adaptation of vector to new cultivars (Dahal et al. 1990). It is believed that Indian isolate of RTD is different from that of Philippines as they showed differential reaction to different varieties. The present study was conducted to found the resistance sources for both the isolates of RTD, Indian as well as Philippines.

MATERIALS AND METHODS

Thirty Indian traditional rice varieties, resistant or moderately resistant, to RTD under field conditions (Malik et al. 1993) at the National Bureau of

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Plant Genetic Resources, Cuttack (India), were evaluated at IRRI using mass screening test (MST) and field screening test to determine their resistance to the Philippines isolate of RTD. The varieties which showed severity score of 7 or less in the MST at IRRI (Table 1) were further tested for resistance to RTBV and RTSV using forced inoculation test (FIT) with TN1 as control (Table 2). Virus free adults GLH were given 4 days of access to rice cultivar TN1 infected with RTBV. Seven days old seedlings growing in a test tube were infected with three viruliferous GLH for 24 h in two replications and 20 seedlings/replications. Inoculated seedlings were later transplanted in pots, sprayed with insecticide inside a green house. Youngest leaf samples from the test plants were collected 30 days after inoculation and tested for the presence of RTBV and RTSV by ELISA method.

Table 1. Screening of Indian rice germplasm lines against RTD at CRRI, Cuttack and IRRI, Philippines

Collector No.	Variety	IRRI	CRRI	IRRI	IRRI	IRRI	IRRI	MST/FIT/FS Score
		Insect resistance	MST Score	MST Rating	MST Score	FIT Score	FS Score	
D12	Kakirinou	7	5	MR	9	9	9	S/S/S
D115	Paddy	7	3	R	9	8	9	S/S/S
D154	Ratnachudi	7	4	MR	9	8	9	S/S/S
D155	Ratnapakhia	7	2	R	NT	NT	9	NT/NT/S
D176	Baniamalta	7	3	R	9	7	9	S/S/S
D219	Kanthakamala	7	3	R	8	6	9	S/MR/S
D281	Dhabkuji	7	3	R	9	NT	9	S/NT/S
D699A*	Jonwphool	3	3	R	5	3	3	MR/R/R
D725	Bhutia	7	3	R	9	8	9	S/S/S
D747	Kanali	7	5	MR	7	5	9	S/MR/S
D786	Lohana	7	5	MR	9	9	9	S/S/S
D814	Basмата	9	3	R	9	9	6	S/S/MR
D829	Dhusuri	7	5	MR	9	9	9	S/S/S
D914	Kanyasar	7	5	MR	8	5	9	S/MR/S
D956	Jagar	NT	5	MR	8	7	NT	S/S/NT
D1253	Basmati	5	5	MR	8	8	8	S/S/S
D1422	Jaldubi	7	5	MR	7	NT	9	S/NT/S
D1549	Bedubhajana	3	5	MR	9	9	6	S/S/MR

D1556	Dhusuri	NT	5	MR	9	7	NT	S/S/NT
M256	Chiptidhan	9	5	MR	7	7	9	S/S/S
M265*	Mundadhan	7	5	MR	5	2	4	MR/R/MR
M266*	Sonakathi	7	5	MR	4	2	4	MR/R/MR
M269*	Malsundri	7	5	MR	5	3	3	MR/R/R
M302	Kendulkathi	7	5	MR	8	6	9	S/MR/S
M303	Molidhan	7	5	MR	6	8	9	MR/S/S
M305	Kharandi	7	5	MR	4	4	9	MR/MR/S
M392	Ushagondhi	NT	5	MR	8	NT	NT	S/NT/NT
M394	Umusi	5	5	MR	8	7	7	S/S/S
M430*	Tulsidash	9	5	MR	6	3	3	MR/R/R
JBT2/225	Jhilli		5	MR	9	NT	NT	S/NT/NT
TN1			9	S	9	9	9	S/S/S

*0-9 score of damage in both RTD and GLH based on Standard Evaluation System of rice, IRRI, 1990.

Table 2. Presence of RTBV and RTSV in R/MR rice varieties tested by ELISA

Collector No.	Variety	Seedlings tested (no.)	RTBV	RTSV	RTBV	RTSV
			ELISA (%) infection	ELISA (%) infection	ELISA Av reading	ELISA Av reading
D219	Kanthakamala	32	87	43	0.67	0.42
D699A	Jonwphool	27	70	0	0.69	0
D747	Kanali	33	90	40	0.66	0.38
D914	Kanyasar	29	88	55	0.63	0.35
M265*	Mundadhan	31	90	0	0.71	0
M266*	Sonakathi	31	100	0	0.73	0
M269*	Malsundri	32	90	0	0.73	0
M302	Kendulkathi	28	86	37	0.71	0.46
M305	Kharandi	31	100	12	0.71	0.44
M430	Tulsidash	29	100	88	0.72	0.49
	TN1	28	100	50	0.91	0.52

Each variety was grown in the field at IRRI surrounded by susceptible check TN1 for field screening during 1995 wet season. Sufficient population of viruliferous GLH was introduced to the field during the early vegetative stage of the plant to enhance the RTD infection. Disease score was taken 30 and 45 days after transplanting (Table 1).

RESULTS AND DISCUSSION

Results revealed that Jonwphool, Mundadhan, Sonakanthi and Malsundri were not infected with RTSV but have high titer of RTBV. Kanthakamala, Kanali, Kanyasar, Kendulkathi, Kharandi and Tulsidas had both RTBV and RTSV. The low severity score of these varieties in FIT may be due to the tolerance of these varieties to RTD infection.

Varieties Jonwphool, Malsundri and Tulsidas showed resistance and Basmata, Bedubhajana, Mundadhan and Sonakathi showed moderate resistance to RTD in the field test at IRRI. The resistance of these varieties to the Philippines GLH vector population was also evaluated. Many of these varieties are susceptible to the GLH at IRRI (Table 1). Resistance/ moderate resistance of Jonwphool and Bedubhajana towards RTD may be due to the resistance of these varieties to GLH. Previous studies have suggested that there is marked variation among the Indian and Philippines isolates of RTD. The present results confirmed these views. We found that some resistant varieties from India also serve as a source of resistance to the Philippines isolate of RTSV.

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GENETIC DIVERGENCE STUDIES IN WHEAT GERMPLASM USING NON- HIERARCHICAL EUCLIDEAN CLUSTER ANALYSIS

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Four hundred and forty-one wheat germplasm collections including important varieties and exotic and indigenous accessions were evaluated for 15 metric characters using non-hierarchical Euclidean cluster analysis. All the genotypes were grouped into 12 different clusters showing existence of high genetic diversity in the material. The genotypes of heterogeneous origin were grouped in the same cluster indicating non-parallelism between genetic and geographic diversity. The intra-cluster distance was maximum (2.90) in cluster II and minimum (2.10) in cluster V. Cluster IV and X were highly diverse (6.66) from each other. Genotypes of cluster IV were the highest yielders ($X = 48.57$ g, C.V. 23.80%). Several collections which may serve as good genetic donors for high spikelet fertility, dwarfness, long ear, bold grain, high number of ears and good source for multiple resistance against rusts and powdery mildew were identified.

Key words : Wheat, germplasm, divergence, cluster analysis

Multivariate analysis based on Mahalanobis D^2 statistic and canonical analysis have the limitations for classifying huge germplasm collections studies for several attributes (Arunachalam, 1981). Beale (1969) suggested the use of Non- Hierarchical Euclidean analysis to overcome these limitations. However, the utility of this analysis for choosing parents for generating good segregates has received very little attention. Hence, the present study was undertaken to study the nature and extent of genetic variability and divergence in the sufficiently large germplasm and also to identify the genetic stocks which may serve as potent donors for yield and yield contributing characters and resistance for common diseases.

MATERIALS AND METHODS

The experimental material consisted of 441 indigenous and exotic germplasm collections of wheat (*Triticum aestivum* L.) representing primitive

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cultivars, land races, old obsolete varieties, current cultivated varieties and special genetic stocks alongwith three check varieties, viz. Sonalika, UP 368 and HD 2329. The genotypes selected for the study were highly diverse geographically as well as genetically and exhibited wide range of variation for morphological, developmental and agronomic characters. These genotypes were evaluated in an augmented design under good fertility and irrigated conditions. Each plot consisted of two rows, each one meter long with 23 cm row to row and 10 cm plant to plant spacing. Observations were recorded on single plant basis on 15 yield and yield contributing characters. A separate nursery of the entire collection used in the above experiment was raised in hill plots for screening against the prevalent diseases.

Analysis of augmented design was done following Federer (1956). Genetic divergence was studied using method of Non-Heirarchical Euclidean cluster analysis (Beale, 1969 and Spark, 1973).

RESULTS AND DISCUSSION

The analysis of variance indicated that there was considerable inherent genetic differences between the check varieties and block effects were in general non-significant except for flag leaf area, plant height and extrusion peduncle length.

Table 1. The general means, variance, coefficient of variability and range for 15 quantitative characters

	Characters	mean	Variance	C.V. (%)	Range
1	Flag leaf area (cm ²)	41.65	117.69	26.05	14.17 - 75.55
2	Plant height (cm)	103.09	346.44	18.05	37.46 - 195.06
3	Grains per ear	64.17	246.37	24.46	26.62 - 11.62
4	Peduncle length (cm)	21.39	4.45	9.86	13.36 - 30.34
5	Extr. peduncle length (cm)	17.06	26.64	30.25	2.83 - 31.94
6	Ear length (cm)	13.29	4.03	15.10	4.71 - 22.39
7	Spikelets per ear	20.97	5.07	10.74	14.50 - 25.96
8	Grains per spikelet	4.51	0.53	16.14	2.74 - 8.87
9	Tillers per plant	23.06	54.76	32.09	4.37 - 56.67
10	Yield per ear (g)	2.73	0.82	33.17	0.55 - 6.65
11	100-grain weight (g)	4.19	0.83	21.74	1.87 - 8.76
12	Ears per plant	19.21	37.10	31.71	4.63 - 46.57
13	Biological yield (g)	102.29	2736.94	51.14	24.98 - 260.58
14	Harvest index (5)	33.47	58.87	22.92	6.19 - 50.91
15	Grain yield per plant (g)	33.75	200.37	41.94	6.68 - 94.11

The general means, variances, coefficient of variability and range for different characters are given in Table-1. Existence of sufficient variability in a crop is an inevitable requirement for effective breeding programme. High values of coefficient of variability were obtained for biological yield, grain yield per plant, yield per ear, tillers per plant, ears per plant and extrusion peduncle length. These results are corroborative with the findings of Randhawa *et al.* (1975) and Sharma *et al.* (1981). The relative contribution of yield *per se* and biological yield towards genetic diversity was very high. This suggests that choosing parental material for attempting crosses only on the basis of grain yield and biological yield is likely to throw useful transgressive segregants. Peduncle length and number of spikelets per ear exhibited the lowest coefficient of variability, while variability was moderate for flag leaf area, plant height, number of grains per ear, ear length, number of grains per spikelet, 100-grain weight and harvest index which indicated that more variability needs to be included or generated for these characters.

Non-hierarchical euclidean cluster analysis proved quite useful for estimating the genetic divergence utilizing the unreplicated data in the large germplasm collections. All the 441 wheat genotypes were grouped into 12 clusters (Table-2). This grouping indicated considerable amount of genetic

Table 2. Estimates of average intra - and inter-cluster distances

Cluster number	Number of genotypes	Mean grain yield (g)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
I	42	24.13	(2.47)	5.45	3.98	4.50	3.46	3.86	3.01	2.86	2.39	4.66	3.35	3.23
II	49	48.17		(2.90)	5.41	2.92	2.78	3.83	4.78	3.03	6.99	2.73	4.04	3.31
III	20	31.55			(2.69)	4.37	3.89	4.42	4.32	4.70	5.43	4.23	4.32	3.32
IV	27	48.57				(2.42)	2.64	4.39	4.58	2.68	6.62	6.66	4.91	3.09
V	42	37.15					(2.10)	3.16	3.43	2.24	5.31	2.70	2.86	2.83
VI	35	29.72						(2.64)	5.05	3.28	5.16	4.85	3.36	3.17
VII	29	27.61							(2.64)	3.16	3.59	3.25	2.57	3.15
VIII	48	32.45								(2.49)	4.55	3.07	3.22	2.38
IX	37	18.77									(2.82)	6.14	3.87	4.56
X	26	47.47										(2.41)	3.71	2.71
XI	39	29.70											(2.50)	3.02
XII	47	32.94												(2.31)

Values in parenthesis are intra-cluster distances

diversity in the germplasm. The genotypes of indigenous germplasm were scattered in more than one cluster and similarly the genotypes of exotic germplasm were distributed in different clusters, e.g. genotypes like, CPAN 1959, W 3422, HUW 100, HD 2285, SMR-44, B, H 256-13-7-1, HB-611-A, DL-181-10, OL-129-3, LoK-3, PBW-27, HP-1209, HI-617, J-392, NI-8365, HW-706, CPAN-2001 and UP-368 although had heterogeneous origin and/or region but were present in the same cluster X. Other clusters also behaved in similar fashion. Therefore, it is concluded that there is no parallelism between genetic and geographic diversity. These findings are, in general, agreement with the results obtained by Murty and Arunachalam (1966), Lee and kaltsikes (1973), Garg and Gautam (1988) and Walia and Garg (1996). However, in past, ecogeographical diversity has been largely relied upon as an index of genetic diversity (Griffing and Lindstorm, 1954). Further, the genotypes of the same cluster had little divergence from each other with respect to the aggregate effect of the fifteen characters examined. Therefore, the hybridization among the genotypes of the same cluster is not desirable for developing good segregates. Inter and intra-cluster distances provided index of genetic diversity among and within the cluster. Maximum genetic distance was observed between clusters IV and X. The crosses between the genotypes from these clusters may give putative transgressive segregates. The further choice of the genotypes may be done considering disease and insect reaction, quality and lodging resistance, etc. The genotypes occupying top positions in a superior cluster may further be assessed for their combining ability and gene effects following suitable mating designs.

The screening of germplasm helped in identifying promising genetic stocks (Table 3) which may serve as good source of high spikelet fertility,

Table 3. Important genetic donors identified from exotic and indigenous germplasm for different characters

High spikelet fertility	CPAN 1842, Lr 25 ransee, HUW 100, CPAN 1947, K 7938, WSM-159-1, NI 8611, H-220-3-3-1, IC 31-6 & DL-214-1.
Long ear	H-256-36-5, Kleititan, CPAN 1997, Hope, NI 8611, IC-310-6, IC 23-3, HW 706, IC-29-1 & H 284-3-2B
Bold grain	Lok-1, CPAN 1885, Hy b 65, VL 493, BR 3087, HI 8-62, Mukta (HI 385), DL-205-1, H-264-30-3 & IC 143-3
High yield	WG 2009, SN 1198, Sr Tt 2, H-256-13-7-1-, CPAN 1969, DL 20-9, HW 838, HW 706, H-284-30-2B & DL-172-1
High ear number	Lr 25 Transee, CAPN 1581, W 3286, Maniton, Rai 1774, WG 357, H-220-20-1, HW 706, H-284-30-2B & DL 172-1.
Dwarfness	CPAN 1419, UP 301, D 6899, 3948 A1, Tordo 'S', Oleson Dwarf & Norin-10.

long ear, bold grain, high yielding types, high number of ears per plant and dwarf types. The germplasm expressed a wide range of variability for morphological characters also. Several rusts and powdery mildew stocks were identified. Accordingly, Rai 1865, CPAN 1959, H 263-106-6-1, CPAN 1991, UL 493, E 8163, UP 301, H 264-100-1-1, VL 608, HW 838, HW 865, K 7931, CPAN 2003, CPAN 2009 and CPAN 2010 may serve as good source for multiple resistance against rusts and powdery mildew in wheat. The germplasm used in the present study may have useful gene (S) for quality improvement and various edaphic and climatic stresses viz. water, salt, alkali and high temperature. Further screening of these materials for these attributes is thus suggested.

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IDENTIFICATION OF NEW MALE STERILE LINES IN PEARL MILLET GERMPLASM

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To identify naturally occurring cytoplasmic male sterility (CMS) in pearl millet [*Pennisetum glaucum* (L.) R. Br.], 4950 germplasm accessions were screened and identified 67 male-sterile plants and sterility maintainers from 16 different germplasm accessions. Of these, eight CMS lines were found to be stable over locations, seasons and years. CMS lines DSA 105A and DSA 134 A from Ghana flowered 7-8 days earlier than 5141A and are less sensitive to extended daylength indicating their wider adaptability. To study the cytoplasmic relationships, the maintainers (B lines) of new CMS lines were crossed with the A lines of existing CMS sources and vice versa. Since DSA 105B and PMC 23B maintain sterility in A₁, A₂ and A₃ CMS systems, they were considered to have different cytoplasm. When the new CMS lines were crossed with 18 diverse pollinators, hybrids with Ghana CMS lines flowered early and produced more grain than the check hybrids. Downy mildew resistant CMS lines DSA 105A and DSA 134 are used to produce hybrids which are being evaluated in India and Niger.

Key words : Male sterile lines, pearl millet, germplasm.

Most commercial hybrids of pearl millet [*Pennisetum glaucum* (L.) R. Br.] are produced using the A₁ cytoplasmic-genetic male sterility system (CMS), originally found in Tift 23A (Burton, 1958). Two additional CMS systems designated as A₂ and A₃ were found from Ludhiana, India (Burton and Athwal, 1967). However, they have not been widely used (Rai and Singh, 1987). As the hybrids produced on Tift 23A became susceptible to downy mildew, and was replaced by several downy mildew resistant CMS lines produced by genomic substitution or induced mutations (Anand Kumar and Andrews, 1984; Pokhriyal et al., 1976; Appadurai and Sambathkumar, 1976; Aken'Ova and Chheda, 1981; Akenova, 1985). Chemical mutagens like ethidium bromide (Burton and Hanna, 1976) and mitomycin and streptomycin (Burton and Hanna, 1982) were used to produce CMS lines. CMS lines were also developed by genomic substitution of *Pennisetum glaucum* subspecies *monodii* with the cultivated line Thiotande (Marchais and Pernes, 1985). Mutations for fertility restoration and maintaining sterility were also reported (Burton, 1972; 1977).

Stable sterile cytoplasm identified from the wild relative *monodii* designated as A4 (Hanna, 1989) was also found to be highly susceptible to downy mildew when grown at ICRISAT Asia Center (IAC), Patancheru during 1990.

To overcome the problems of narrow cytoplasm base, it is desirable to identify new sources of stable downy mildew resistant CMS lines. Hence, we searched for spontaneously occurring CMS lines in exotic introductions. This paper describes the method of identifying spontaneously occurring CMS lines in pearl millet, their morphological characteristics, and stability over seasons, years, and locations, cytoplasmic relationships with the existing CMS lines and the performance of hybrids produced using these CMS lines with 18 diverse pollinators.

MATERIALS AND METHODS

ICRISAT had assembled 21,919 pearl millet germplasm accessions from 44 countries. As and when they were received, all the exotic pearl millet introductions to ICRISAT were space planted in Post-Entry Quarantine Isolation Area (PEQIA) for quarantine inspection and seed increase. To prevent outcrossing, emerging heads were bagged before stigma emergence (Mengesha and Appa Rao, 1986). When these growouts were carefully observed, we found naturally occurring male sterile plants. During the first growout in PEQIA at IAC, Patancheru, about 200 plants per accession were space planted. Before stigma emergence, heads were bagged and observed 10 days later for seed set. Those heads which did not produce seed were carefully examined for anther morphology and those plants with shrunken, shrivelled anthers and did not produce any pollen were isolated. In such plants, seed set under open-pollinated spikes was also observed. Such selected plants were given extra care by providing irrigation and fertilizers. Sister plants with desirable agronomic characters were also given extra care. Newly emerging spikes of the suspected male sterile plants were pollinated with the sister plants and their progenies were tested for fertility after bagging. Progenies in which there was no seed set were considered as male sterile (A line) and the male parent as the sterility maintainer (B line). These plants in which there was no seed set in selfed heads in A lines and which produced seed upon crossing with sister plant (new B lines) with desirable agronomic characters were advanced. To improve the level of downy mildew resistance, these A and B lines were also grown in downy mildew sick plot (Singh and Gopinath, 1985). Pollen from downy mildew free B plants only were used to pollinate downy mildew free A plants.

For morphological characterization, A and B lines were grown along with the popularly used CMS lines 5141A and ICMA 1 (81A) and the morphological characters were recorded according to the pearl millet descriptors (IBPGR/ICRISAT, 1993).

To study the cytoplasmic relationships with A₁, A₂ and A₃ sources, B lines of these three sources were crossed with the newly developed CMS lines. Similarly, the B lines of the new CMS lines were crossed to the A lines of A₁, A₂ and A₃ sources. Tift 23 d₂, Tift 239 and L67 were used for A₁, A₂ and A₃ sources, respectively. Some of the known restorers were also used as male parents on the new male sterile plants. Fifty F₁ plants from each cross were grown and seed set was observed in 5-10 bagged heads. Considering seed set in bagged heads they were classified as restorers, maintainers or partial steriles where seed set was about 20%. To ascertain whether the new CMS lines produce good hybrids, they were crossed with 18 diverse elite pollinators and the F₁ hybrids were grown along with the parents for comparison. These CMS lines along with hybrids produced on them were evaluated at four locations in India; Bhavanisagar (11°00'), Patancheru (17°22'), Gwalior (26°12'), and Hisar (29°10') during three years.

RESULTS AND DISCUSSION

Identification of male sterile plants

CMS plants were morphologically conspicuous as they were producing more than 10 tillers per plant compared to 3-5 in the fertile plants. These CMS plants with profuse tillers were sequential in flowering, and seed set was absent in the selfed heads. Open-pollinated heads of such plants or those heads pollinated with fresh pollen produced full seed set. The anthers of CMS plants were shrivelled, shrunken and did not emerge completely out of the florets compared to those fertile anthers which were large, plump and emerged completely. When the shrunken anthers were crushed and pollinated on the established male-sterile line 5141A, there was no seed set. These pollen grains did not stain with acetocarmine or iodine solution. Those plants which did not set seed after bagging but showed good seed set after open pollination or after hand pollination were considered as male sterile. The fertile plants which produced sterile plants in the next generation after crossing with the fertile plants were considered as a sterility maintainer or B line. Even though, we found male sterility in 16 different accessions during the first generation, the progenies of eight accessions produced 5-20 seeds inside the bagged heads. We advanced only 8 accessions which did not produce seeds in bagged heads. Partial sterility of some of these lines might be due to the fact that sterility was influenced by environment or there were several modifier genes. Stable male-sterile plants (A lines) and sterility maintainer plants (B lines) were derived in 5 accessions from Ghana, 2 accessions from Botswana and 1 accession from Togo.

All the accessions which had segregated for CMS were collected by ICRISAT. The precise locations from where these CMS lines collected were

described elsewhere (Appa Rao *et al.*, 1989). All the CMS lines from Ghana which segregated for male sterility were collected around Bolgatanga in northern Ghana. While both the CMS lines from Botswana were collected in Kgatleng district which is a very dry area. The CMS line ARD 132 was collected from northern Togo which is relatively a high rainfall area (Appa Rao *et al.*, 1990).

To identify new sources of CMS, we screened an estimated one million plants from 4950 accessions from 18 countries. Of the 4950 accessions screened, 16 accessions from Botswana, Central African Republic, Ghana, Sudan, Tanzania and Togo had CMS plants (Table 1). The spontaneous mutation rate calculated per accession was 0.032. However, when mutation rate was calculated as percentage of mutant (CMS) plants to the total plants screened, the mutation rate was 0.0067. Spontaneous mutations for CMS appear to occur at a very low frequency. The percentage of mutant plants was 2.17 which was very low probably because we collected seeds from at least 30 plants. CMS plants must be in the original population because we found them during the first

Table 1. Frequency of spontaneous male sterile (CMS) plants identified in pearl millet germplasm from different countries.

Pedigree	Origin	Frequency of plants		% of CMS
		Normal	CMS	
PMC 23	Botswana	170	4	2.35
PMC 30	Botswana	180	3	1.67
AK 140	Central Africa	192	4	2.08
DSA 27	Ghana	175	1	0.57
DSA 59-1	Ghana	151	5	3.31
DSA 105	Ghana	172	3	1.74
DSA 118	Ghana	152	7	4.61
DSA 134	Ghana	168	5	2.98
DSA 144-1	Ghana	145	4	2.76
DSA 194-1	Ghana	176	3	1.70
PGI 2	Sudan	193	2	1.04
ACC 544	Sudan	158	3	1.90
M 70-1	Tanzania	161	2	1.24
ARD 51	Togo	174	6	3.45
ARD 56	Togo	182	2	1.10
ARD 132	Togo	538	13	2.42
Total		3087	67	2.17

growout and they must have been maintained because of cross pollination. Such mutations appear to be occurring in a relatively high frequency in the material collected from Ghana and Togo.

Morphological characteristics

Morphological characteristics of the new CMS lines when evaluated at IAC, Patancheru in two contrasting seasons are given in Table 2. The new CMS lines flowered in 42-60 days in the rainy season and are less sensitive to day length compared to 5141A (Table 2). They grew to an height of 130-200 cm in the rainy and 120-140 cm in the postrainy season. Spike length varied from 14.5 to 25 cm in the rainy season with a slight reduction in the postrainy season. Grain number per spike varied from 460 to 1936 and grain size from 5.8 to 14.3 mg. CMS lines from Ghana have certain desirable agronomic traits such as early flowering and large grain size. Estimated mean grain yield of CMS lines at Patancheru, Bhavanisagar and Hisar ranged from 465 kg ha⁻¹ in PMC 30A to 2352 kg ha⁻¹ in DSSA 134A.

The CMS lines DSA 105A and DSA 134A from Ghana, flowered 7-8 days earlier than 5141A and were resistant to downy mildew. Under extended daylength, a minimum delay of 2 days was found in DSA 105A compared to 15 days in 5141A and 9 days in MS 81A, revealing their wider adaptability. Early maturity, less sensitivity to daylength and large grain size of DSA 105 and DSA 134 are the agronomically desirable characters of these CMS lines. High tillering of PMC 23 and PMC 30 make them potential good forage types.

Cytoplasmic relationships

Seed set in F₁ plants of crosses involving new CMS lines with B lines of A₁, A₂, A₃ are given in Table 3. The sterile progeny was considered as maintainer and hence possessing the same cytoplasm, while fertile progeny was considered to have different cytoplasm. The cytoplasmic relationships of 5 CMS lines from Ghana and 2 from Botswana indicated that DSA 144 possess cytoplasm different from A₁ because the B line of this (maintainer) restored the fertility on A₁ cytoplasm. The B lines of DSA 105 and PMC 23 maintain sterility on A₁, A₂ and A₃ systems.

The sterile cytoplasm from *P. violaceum* in M₁ and M₂ (Marchais and Pernes, 1985) showed considerable differences with the new CMS lines. The B lines of both M₁ and M₂ restored fertility in all the new CMS lines except on PMC 30A. Reciprocal differences were observed in crosses involving DSA 59-1, DSA 105, DSA 144 and OMC 30. No reciprocal differences were observed in DSA 118.

Table 2. Characteristics of the newly identified male-sterile lines of pearl millet from Ghana and Botswana compared with 5141A

Character	DSA 59-1A		DSA 105A		DSA 118A		DSA 134A		DSA 144A		PNC 23A		PNS 30A		ARD 132A		5141A	
	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
Days to 50% flowering-R	50	4.3	43	1.4	47	1.4	42	0.7	53	2.3	55	1.4	60	0.5	46	1.8	50	0.7
" " -PR	58	3.8	45	0.7	52	1.4	49	2.1	55	3.1	62	2.1	13	1.4	43	2.6	66	1.4
Plant height (cm)-R	140	2.0	140	2.2	140	7.7	130	11	140	1.8	145	7.1	120	1.5	200	1.7	131	2.8
" " -PR	120	1.6	120	1.6	125	11	130	21	100	2.4	135	3.5	120	1.7	140	2.6	70	0.7
Spike length (cm)-R	16.0	2.6	22.5	2.3	14.5	5.7	16.0	1.4	17.0	1.2	24.0	3.5	20.0	1.5	25.0	1.4	17.0	2.1
" " -PR	15.0	3.4	17.0	1.4	15.0	2.8	17.0	0.7	13.0	1.8	22.0	0.7	17.0	1.6	17.0	2.1	11.0	1.4
Spike thickness (mm)-R	25.0	1.5	24.5	3.5	24.0	0.7	19.0	2.1	22.0	3.2	23.0	1.4	18.5	2.0	34.0	2.6	14.0	2.5
" " -PR	26.0	2.7	28.0	4.2	23.0	0.7	23.0	4.2	17.0	2.6	22.0	3.5	20.0	1.7	28.0	2.1	12.0	0.7
No. of spikes/plant-R	4.5	3.4	2.5	1.8	3.5	2.4	4.2	1.3	4.3	1.8	3.4	2.4	6.8	2.1	2.8	1.2	5.3	2.6
Spike exertion (cm)-PR	3.0	1.4	8.0	1.6	9.0	2.3	9.0	1.5	2.0	4.5	3.0	1.4	2.0	1.8	10.0	1.6	5.0	0.6
No. of grains/spike-PR	1062	2.8	1485	3.4	1615	2.7	1450	2.5	460	2.8	1281	1.9	1485	2.8	1936	4.7	2056	1.8
1000 grain mass (g)-PR	12.8	1.8	14.1	2.0	12.5	1.9	14.3	0.7	9.0	0.8	12.6	1.5	5.8	2.5	14.1	1.2	6.2	0.5

R= rainy (kharif) season, PR = postrainy (rabi) season.

Table 3. Cytoplasmic relationships of newly developed CMS lines with existing sources of cytoplasm

	MS	Tift	L			DSA	DSA	DSA	DSA	DSA	PMC	PMC
Pedigree	81B	239B	67B	M1B	M2B	59-1B	105B	105B	118B	134B	144B	23B
DSA 59-1A	M*	R*	M	R	R	M	M	M*	P	M*	M	M
DSA 105A	P	M	M*	R	R	M	M	M	M	M	M*	M*
DSA 118A	R	R*	P	R	R	M	M	M	M*	M*	M	M*
DSA 134A	P	P	M*	R	R	P	M	M*	M	P	M	V
DSA 144A	X	R	M*	R	X	M	M	M	R	M	M	V
PMC 23A	R*	V	M*	R	R	P	V	M*	M*	M	M	M*
PMC 30A	M*	R	R	M	M	M	M	P	M*	R	M*	M
M1A	M	R	R	M	M	M	M*	R	M*	M	V	M*
M2A	M*	R	R	C	M	M	M	R	V	X	X	R
MS 81A (A1)	M	R	M*	M*	M	M	M	V	M	R	M*	V
T 239A (A2)	R	M	P	R	R	R*	M*	R	V	M	M*	V
L67A (A3)	R	V	M	R	R	R	M*	P	M*	M*	M*	V

M = maintainer, M* = maintainer with 3-7 grains per spike, R = restorer, R* = restorer with incomplete seed set, P = partial sterile, V = variable, X = not available.

DSA 105B is also a maintainer on PC 23A and vice versa indicating that these two have the same cytoplasm. Reciprocal differences were observed in crosses involving Tift 239 (A₂) and DSA 144; crosses involving 239A with DSA 144B, maintains sterility in F₁ whereas the F₁ of DSA 144A with Tift 239B behaved as fertility restorer. Similarly, crosses involving L 67A with DSA 59-1B behaved as a restorer while the reciprocal cross behaved as a maintainer. Such reciprocal differences were also reported by (Rai and Hash, 1990). These reciprocal differences may be due to differences in cytoplasm but they may have the same genes for male sterility. The inbred J 104 which is a restorer on 5141A (A₁ system behaved as maintainer on DSA 105A confirming that the cytoplasm of DSA 105A is different from A₁ system.

Agronomic performance of hybrids

To assess the potential of these CMS lines, 18 diverse pollinators were crossed to the CMS lines and were evaluated for the agronomic traits including grain yield at five locations. The F₁ hybrids flowered 13 days earlier than the CMS lines, grew 35-100 cm taller, and produced longer spikes (Table 4). The increase in grain yield was from 300 to 1400 kgs thus indicating heterosis in the F₁ hybrids. The CMS lines from Ghana and Botswana were found to be resistant to downy mildew in India and Niger.

Seeds of these CMS lines were supplied to several plant breeders in private and public sectors in India and elsewhere. Hybrids produced on DSA

134A with indigenous inbreds from Niger appeared very promising at Sadore in Niger. Early maturity of DSA 105A is being exploited to produce early-maturing hybrids in India.

Table 4. Comparison of CMS lines with the hybrids produced on them with 18 diverse pollinators*

	DSA	DSA	DSA	DSA	DSA	PMC	PMC		MS
Character**	59-19A	105A	118A	134A	144A	23A	30A	5141A	81A
Flowering - P	47.2	47.9	48.9	40.2	54.2	55.0	56.5	54.2	51.8
Flowering - H	46.8	45.7	47.5	45.7	X	X	X	X	50.2
Plant height (cm) - P	168	128	170	150	140	189	155	140	114
" " - H	230	231	223	233	X	X	X	X	228
Tiller number - P	4.2	3.0	2.6	3.8	3.4	3.2	7.0	2.8	2.7
Spike length (cm) - P	17.4	21.7	20.2	18.9	15.9	18.1	18.2	18.9	21.7
" " -H	22.5	22.7	24.1	21.5	X	X	X	X	24.3
1000 grain mass (g) - P	11.2	12.3	13.4	9.4	9.9	10.5	4.8	6.2	6.6
Grain yield (kg-1)-P	2012	1096	1472	2352	2043	1624	465	1389	2003
" " -H	2709	2475	2387	2664	X	X	X	X	2542

* = data based on mean for five locations in India.

**P = seed parent; H = mean of hybrids produced with 18 diverse pollinators, X = no data.

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STUDY ON GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS OF *DOLICHOS* BEAN GERMPLASM OF TRIPURA

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Twenty-two landraces of *Dolichos* bean were collected from Tripura during 1988 and evaluated at Barapani Farm, CIAR Research Complex for NEH Region. A wide range of genetic variability was recorded for all the characters. High heritability accompanied by high genetic advances were recorded in pods/plant, pod yield/plant and pods/panicle. Number of pods/plant, pod yield/plant and panicles/plant were highly associated with pod yield and contributed maximum indirectly via number of pods/plant, while number of pods/plant and single pod weight contributed maximum, directly. Hence for the improvement of *Dolichos* bean by selection, maximum emphasis should be given on these four characters viz. pods/panicle, panicle/plant, pods/plant and single pod weight.

Key words : *Dolichos* bean, landraces, collection, genetic variability, correlation, path analysis.

Dolichos lab lab (Roxd) L. (syn. *Lab-lab purpuria* var. *typicus*) is an important vegetable legume of North Eastern Hill Regions of India. Among the North Eastern states, it is widely cultivated in Tripura for its green pods. Plant of *Dolichos* thrives well in slant sloppy hills and *tilla* land of state. It indicates that climate of the state is quite conducive for the commercial cultivation of this crop in the state. However, a very little attention has been paid with respect to the genetic improvement of this crop, while a number of its landraces with genetic variability are available (Singh *et al.*, 1979, Baswana *et al.*, 1980, Kabir and Sen, 1987) in *Dolichos* bean. Therefore, the present study was planned to explore the landraces of this crop grown in the state and study their genetic variability, correlation and path analysis in order to select suitable genotypes for utilization in breeding programme.

MATERIALS AND METHODS

Twenty-two landraces of *Dolichos* bean were collected from Melaghar, Teliamura, barahmura, Mohanpur, Eshar Hill and Korilong areas of Tripura during November, 1988 and evaluated at ICAR Research Complex for N.E.H.

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Region, Barapani, Meghalaya. Experiment was laid out in randomised block design with three replications during the year 1989-90. Each germplasm accession was sown in hill with spacing of 1.00×0.75 m. Three seeds were sown in each hill and after germination, one plant was allowed to grow in each hill. A basal fertilizer dose of 25 kg N/ha (two splits), 40 kg/ha P_2O_5 and 30 kg K/ha was applied in form of urea, single super phosphate and murate of potash, respectively.

Bamboo staking was done after 3 weeks of sowing. Pod characters were recorded from 10 pods selected at random from third picking. The total of all the pickings from each germplasm was used to compute the number of pods/plant and green pod yield/plant. Observations were recorded on days to flowering (DF), panicle length (PEL), pod length (PL), pod width (PW), pod thickness (PT), single pod weight (SPW), number of pods/panicle (NP/P), and pod yield/plant (PY/P). Heritability (in broad sense) and genetic advances were calculated as per procedures described by Johnson *et al.* (1955). Correlation and path analysis were worked out by as per model given by Panse and Sukhatme (1957) and Deway and Lu (1959).

RESULTS AND DISCUSSIONS

A wide range of variations were observed in colour distribution on pod, stem and flower (Table 1). The pod and stem were grouped into green, red, cream and their different shades, while flowers colour was noted white or red only. Pods were either straight (finger shape) or curved. Among all the germplasm, RCDL-21 bore dark red finger shaped pods, which appeared to be rare material. Most of the germplasm had green or cream pods, green or cream stem and white or red flowers and red or purple pod combination with red stem and red flowers. However, exceptions were also recorded in RCDL-5, RCDL-6 and RCDL-19.

Genetic Variability and Heritability

Data on yield and yield attributes, heritability, and genetic advances are presented in Table 1. The differences among the germplasm lines were significant for all the characters studied. RCDL-18 expressed earliest flowering (77 days after sowing), however, it was statistically at par with RCDL-3 and RCDL-7. The highest pod length was recorded in RCDL-18 followed by RCDL-20 and RCDL-19. Single pod weight was maximum in RCDL-19 (5.98 g). It may be due to the cumulative effect of higher pod width (2.47 cm), pod thickness (0.83 cm) and pod length (11.70 cm). The maximum number of pods/plant was recorded in RCDL-9 (304.1) which was followed by RCDL-10 (283.2). Moreover, maximum pod yield/plant was recorded in RCDL-3 (1.45 kg) and found statistically superior to RCDL-9 (1.16 kg), RCDL-2 (1.08 kg) and RCDL-10

Table 1. Evaluation of *Dolichos lab-lab* var. *tipicus* germplasm

Accession	Pod colour	Stem colour	Flower colour	Pod shape	Days to flowering	Panicle length (cm)	Pod length (cm)	Pod width (cm)	Pod thickness (cm)	Weight/ pod (g)	No. of panicle pods/ panicle (12)	No. of panicles/plant (13)	No. of pods/ plant (14)	Pod weight/ plant(kg) (15)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
RCDL-1	DPR	R	R	SC	87.3	16.67	6.91	1.63	0.80	4.49	6.5	22.7	145.9	0.622
RCDL-2	G	G	W	S	89.0	18.77	10.16	1.76	0.83	5.64	9.1	21.5	192.6	1.082
RCDL-3	LPR	R	R	S	81.0	22.90	9.41	1.52	0.74	4.65	11.1	29.1	212.5	1.451
RCDL-4	G	G	W	S	92.7	26.23	7.24	1.12	0.63	3.18	10.0	17.2	105.7	0.328
RCDL-5	G	G	R	S	89.7	16.73	8.24	1.42	0.64	3.84	8.9	13.7	68.1	0.261
RCDL-6	LPR	G	R	C	92.7	12.93	8.12	1.93	0.75	4.27	5.6	16.8	91.5	0.390
RCDL-7	LPR	R	R	C	81.0	30.96	8.32	1.49	0.63	3.27	10.	20.1	209.3	0.892
RCDL-8	C	C	W	C	85.3	29.23	5.84	1.86	0.74	3.73	9.0	21.8	191.2	0.712
RCDL-9	C	C	W	C	81.0	28.53	6.50	1.91	0.72	3.84	12.3	26.1	304.1	1.167
RCDL-10	C	G	W	C	92.3	25.23	6.10	2.12	0.67	3.67	12.8	22.9	283.2	1.031
RCDL-11	LPR	PR	R	C	99.0	24.33	7.00	1.47	0.69	3.32	8.0	19.7	153.9	0.511
RCDL-12	LPR	PR	R	SC	83.7	21.53	8.88	1.44	0.61	3.26	5.1	17.0	86.9	0.281
RCDL-13	PR	R	R	SC	86.3	29.63	8.11	2.01	0.78	3.98	12.0	20.3	244.0	0.971
RCDL-14	LR	R	R	SC	86.0	32.00	6.53	1.87	0.84	3.87	10.4	24.8	257.4	0.994
RCDL-15	LPR	R	R	SC	93.0	24.63	7.10	1.77	0.82	4.19	9.1	22.5	201.7	0.842
RCDL-16	PG	R	R	S	104.0	20.43	6.93	1.07	0.74	3.69	7.1	20.5	141.8	0.523

(Contd. to next page)

Accession	Pod colour	Stem colour	Flower colour	Pod shape	Days to flowering	Panicle length (cm)	Pod length (cm)	Pod width (cm)	Pod thickness (cm)	Weight/ pod (g)	No. of panicle pods/ panicle (12)	No. of panicles/plant (13)	No. of pods/ plant (14)	Pod weight/ plant(kg) (15)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
RCDL-17	PR	R	R	S	104.3	29.06	8.92	0.94	0.99	4.43	9.1	15.7	140.5	0.619
RCDL-18	G	G	R	SC	77.7	20.87	12.43	2.31	0.72	5.25	4.3	20.5	87.1	0.455
RCDL-19	LPR	G	R	SC	101.0	19.07	11.70	2.47	0.83	5.98	6.2	21.1	124.8	0.762
RCDL-20	LR	R	R	SC	92.3	19.83	12.37	2.32	0.78	5.67	4.6	21.2	94.4	0.536
RCDL-21	DR	R	R	S	100.7	27.23	7.67	0.98	0.87	3.21	4.2	9.8	41.5	0.129
RCDL-22	C	C	W	SC	94.7	24.46	8.37	2.02	0.97	4.33	3.5	9.1	31.9	0.138
SEm					2.88	1.35	0.17	0.06	0.12	0.18	1.09	1.64	26.54	0.105
CD at 5%					4.75	2.23	0.99	0.10	0.20	0.29	1.81	2.70	43.79	0.174
h ² (%)					87.36	93.49	99.32	99.06	26.74	97.17	87.69	89.85	91.66	91.42
GA(%)					16.05	47.69	51.54	52.09	10.36	53.06	71.39	47.33	105.08	104.03

DPR = Dark purple red, G = Green, LPR = Light purple red, C = Cream, PR = Purple red, LR = Light red, PG = Purple green, DR = Dark red, R = Red, W = White, SC = Slightly curved, S = Straight, C = Curved

(1.03 kg), might be due to the optimum single pod weight and number of pods/plant.

A wide range of variation was observed for all the characters. Heritability estimates were high for characters namely, pod length, pod width, single pod weight, panicle length, pods/plant, pod weight/plant, panicles/plant, pods/panicle and days to first flowering (Table 2). In spite of high heritability values for most of the traits, estimate of genetic advance (% mean), ranged from 10.63 to 105.08. High heritability values were associated with high values of genetic advance (% mean) for pods/plant, pod weight/plant, pods/panicle and moderately were obtained for single pod weight, pod width, pod length and panicle length. High heritability accompanied by high genetic advance was more useful than the heritability alone and considerable importance could be made in these characters when predicting the resultant effect for selecting the best individuals (Johnson *et al.*, 1995). High heritability along with high genetic gain indicated in these characters due to considerable additive gene effects (Panse, 1957). In some characters like days to flowering had a high heritability but low genetic gain. Such characters are more likely to be under the control of non-additive gene and selection for this character will be less effective (Panse, 1957). Additive effect for pod yield and pod number have been observed by Arunachala (1979) and Baswana *et al.*, (1980) for *D. lab-lab*.

Table 2. Correlation among certain characters in *Dolichos bean* (pole type)

Character	PEL	PL	PW	PT	SPW	NP/PE	NPE/P	NP/P	PY/P
DF	-0.127	0.315	-0.112	0.458*	0.180	-0.325	-0.519*	-0.443*	-0.302
PEL		-0.458	-0.095	0.117	-0.399	0.541**	0.197	0.499*	0.247
PL			0.262	0.329	0.774**	-0.543**	-0.172	-0.455*	-0.068
PW				-0.089	0.633**	0.120	0.591**	0.342	0.521*
PT					0.263	-0.333	-0.295	-0.198	-0.031
SPW						-0.326	0.224	-0.113	0.360
NP/PE							0.638**	0.879**	0.650**
NPE/P								0.862**	0.868**
NP/P									0.864**

*Significant at 5 % level; **Significant at 1 % level

Correlations

Table 2 presents the data on correlation studies. Analysis of simple correlation between the characters pointed out a significant positive correlation for days to flowering with pod thickness and significantly negative association

with number of panicle/plant and number of pod/plant while loose association with yield/plant. It clearly indicates that early flowering can increase the number of pods/plant and number of panicle/plant might be due to prolonged fruiting periods and *vice-versa* with late flowering. In agreement with the present observations, Arunachala (1978) also reported positive correlation between number of pods and pod yield. Number of panicles/plant has significant association with pods/plant and pod yield/plant (Joshi, 1971).

Path Analysis

The maximum direct effect (1.315) was contributed by number of pods/plant followed by single pod weight (0.694). The positive direct effect of number of pods/plant was somewhat diminished by the factors i.e. days to flowering (-0.008), panicle length (0.032), pod width (-0.072), single pod weight (-0.079), number of pods/panicle (0.012) and number of panicles/plant (-0.186), thereby accounting a highly significant correlation of 0.864. The direct effect of number of panicles/plant was negative (-0.216) but very high indirect effect *via* number of pods/plant (1.133), gave significant correlation (0.868) to the yield/plant. Similarly, number of pods/panicle was negative direct effect (-0.139) but positive indirect effect (1.156) contributed strong toward a significant correlation (0.650). The direct effect of pod length (-0.080) was negative but due to positive indirect effect *via* single pod weight (0.537) and negative *via* number of pods/plant (-0.599) contributed negligible to the yield/plant (-0.069) Table 3. This was apparent in long-podded genotype in RCDL-18 and RCDL-20 having minimum number of pods/plant and it reduced yield/plant. The contribution of the residual factor was worked out as 0.0156.

Table 3. Path analysis in *Dolichos* for pod yield/plant

[illegible]

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SELECTION CRITERIA FOR SALT TOLERANCE IN LENTIL GERMPLASM I. GERMINATION AND SEEDLING TRAITS

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The study was conducted for salt tolerance capacity and variability in lentil germplasm at different levels of salinity. The observations on 60 genotypes indicated a significant reduction in germination and seedling characters at varying levels of salt stress upto 16.3 ds/m EC. A combination of high germination and above 1 plumule/radicle ratio can give a criteria for selection of tolerant genotypes.

Key words: Lentil, salt tolerance, selection criteria

One of the emerging problem of world agriculture in general and for Indian subcontinent in particular is the paucity of additional agricultural land for crop production. Salinisation of soil in arable lands has further reduced the area for cultivation. In India, around 5.5 m ha land is affected by salinity and 3.58 m ha by alkalinity, out of which 1.58 m ha alone is reported to be in state of Uttar Pradesh (Anonymous, 1993-94).

The productivity of such lands falls steeply and threat to irrigation systems is posed as well. Salt tolerant plant species of cultivars are valuable in such situations to maintain productivity in agriculture. However, it is often suggested that genetic mechanisms of salinity tolerance can be used towards economic utilisation of saline soils. The pulses might have an added advantage under such soils due to their soil ameliorating properties, as compared to cereals. Although in cereals, like rice, the mechanism of salt tolerance has reached the level of commercial utilisation with the release of tolerant varieties, the studies in pulses are still at preliminary stage. Most of the literature is confined to varietal testing while germplasm is still unexploited.

Lentil being a grain legume of cold season may suit such land after cultivation of salt resistant rice in rainy season for Indian conditions. The extent of genetic diversity for salinity tolerance in lentil germplasm has not been explored and the techniques for measurement of salt tolerance are yet to be standardised.

The present investigation is aimed at 1) gaining preliminary information on existence of salt tolerance capacity and variability for this trait in lentil germplasm and 2) gaining idea about relative characteristics to be utilized for standardisation of evaluation technique or selection criteria under salt stress.

The part of the above mentioned objectives is the subject of this paper.

MATERIALS AND METHODS

Like many other leguminous crops lentil is also sensitive to salt stress right from germination to seedling stage and upto adult stage (Asrof *et al.*, 1986). The material included small to bold seeded indigenous and exotic accessions (genotypes) from existing germplasm collections at Pantnagar. The sixty genotypes were screened under incubator conditions using sodium chloride (NaCl) solution of electrical conductivity (EC) values as 0, 4.15, 7.75, 11.53 and 16.3 ds/m. The solutions were prepared using reagent grade NaCl in deionised water. At 0 EC no salt was added while for other EC solution, 0.316, 0.539, 0.876 and 1.18 g NaCl was dissolved per 100 ml of water respectively to get desired EC values. The EC of these solutions were measured by conductivity bridge (CC 601) as per procedures given by Jackson (1958). The cell constant value was at 1.08. Five litre solution of each EC were prepared to conduct germination experiment. The seeds of all genotypes were surface treated with Thiram (Tetramethyl thirum disulphide) at the rate of 2.5 g/kg seed and 100 seeds of each genotype were kept on towel paper soaked in the NaCl solutions of different ECs. The rolled towel papers were fastened with rubber bands and kept in the trays vertically at 25°C with relative humidity 80% following the International Rules for Seed Testing (Anon, 1976). Each genotype was replicated three times at all conductivities. The observations on germination percentage at 5th and 10th day after incubation were recorded. The other observations, plumule length, radicle length, plumule radicle ratio, plumule and radicle growth per day were taken on five randomly tagged seedlings on 5th and 10th day.

The germination percentage data were arc sine transformed and analysis of variance for all variables was carried out as factorial set with main plots in randomised block design, the factors being genotypes (60), salt concentrations (5) and days (2) as per procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The table of means at different salt concentrations for germination and other seedling traits have been given in Table 1. The germination at 0 EC salt level was 90% with most of the genotypes showing above 77% values which is within the normal limits since the osmotic conditions were normal.

Table 1. Mean values* of different characters in lentil germplasm at various salt concentrations

Characters	Salt levels (NaCl)				
	0 ds/m	4.15 ds/m	7.75 ds/m	11.53 ds/m	16.3 ds/m
1) Germination (%)	90.00	81.00	80.00	62.00	55.00
2) Plumule length (cm)	8.30	4.09	2.35	1.37	1.03
3) Radicle length (cm)	6.82	3.14	2.43	1.58	1.29
4) Plumule-Radicle ratio	1.15	1.15	0.92	0.85	0.79
5) Plumule Growth/day (cm)	1.72	1.14	0.45	0.23	0.15
6) Radicle Growth/day (cm)	1.06	0.56	0.25	0.40	0.10

*Values pooled on 5th and 10th day

As the salt concentration increased to EC value 4.15 ds/m, the overall germination declined to 81%. The genotypic behaviour changed slightly in degree where highest germinating genotype (at 0 EC) DLG-100 showed lower germination of 89%. The highest germination was obtained by DGL - 191 (92%). Thus genotypic variability started appearing at 4.15 ds/m but without substantial loss in character. The drastic reduction in germination was observed at 11.53 and 16.3 ds/m with values of 62% and 55%. Although optimum types with germination 84% (L-201/83) and 74% (DLG-100) were obtained at 11.53 ds/m, no genotype could maintain sufficient germination at 16.3 ds/m due to high salt concentration. Such trends have been reported in chickpea, pea, field bean and groundnut (Saxena and Rewari, 1992; Nautiyal, 1989; Jaiswal *et al.*, 1975; Singh and Prakash, 1986). It was also observed that the genotypic behaviour did not show similar trends at different salt concentrations (Table 2).

The reduction in the values of other characters (Table 1) did show a moderate to heavy reduction with increasing salt concentrations. The longer plumule lengths were observed (data not presented here) in the genotypes with high germination count. The genotypes DLG-100 and DLG-72 had not only higher germination count but longer plumule length. The length of plumule is a good measure of seeds to develop into good seedlings at an early stage. The values of mean squares (Table 2) for genotypes, concentration, days and all interactions involving main effects were statistically significant indicating the specific response of a particular genotype to graded level of salinity.

The trends were similar for radicle length. The drastic reductions in radicle length were obtained beyond 7.75 ds/m possibly due to osmotic inhibition of water availability, toxic effects of ions on roots and nutritional imbalances (Gupta, 1977).

Table 2. Analysis of variance for different characters at various salt concentrations in lentil germplasm

Source	df	Germination percentage			Plumule length			Radicle length			Plumule/radicle +,		
		MS	CD	SEM	MS	CD	SEM	MS	CD	SEM	MS	CD	SEM
Replication (R)	2	5.38			7.01			6.48			0.56		
Genotypes (G)	59	60.93*	0.72	0.36	2.13**	0.34	0.17	1.61**	0.32	0.11	0.29**	0.10	0.05
Concentrations (C)	4	2331.15**	0.20	0.10	3177.37**	0.09	0.05	1786.23**	0.06	0.03	10.03	0.02	0.01
Days (D)	1	1267.16**	0.13	0.06	6306.67**	0.06	0.03	1984.16**	0.04	0.02	119.86**	0.01	0.009
G × C	236	23.13**	1.62	0.82	1.75**	0.77	0.39	0.81**	0.26	0.13	0.22**	0.11	-
C × D	4	325.69**	1.02	0.52	1015.48**	0.48	0.24	382.02**	0.32	0.16	4.22**	0.14	0.07
G × D	59	13.70**	0.29	0.15	1.16**	0.14	0.07	0.75**	0.09	0.04	0.10**	0.04	0.02
G × C × D	236	6.89**	2.29	1.16	1.31**	1.09	0.55	0.44**	0.73	0.37	0.09**	0.32	0.16
Error	1198	2.04	-	-	0.46	-	-	0.21	-	-	0.04	-	-
Total	1799	14.37	-	-	13.65	-	-	6.31	-	-	0.16	-	-

**Significant at 1% level of significance

MS = Mean square

CD = Critical difference

SEM = Standard error of mean

In the present study, the plumule/radicle ratio which is a direct function of plumule and radicle growth was found as a possible criteria to screen germplasm for salinity tolerance. The ratio gets reduced with increasing salinity levels, thus the proportional growth of plumule and radicle is lost and radicles tend to become longer.

A high ratio (> 1) can be a good indication of salinity tolerance due to higher water absorption capacity and better growth under saline conditions. The genotypes with longer plumule than radicle were considered tolerant types under salt stress. Some genotypes having high plumule/radicle ratio (> 1) have been presented in Table 3. Such trend have also been reported by Sharma (1991) in his studies with faba bean.

Table 3. Germination (%) and Plumule radicle ratio of promising genotypes under 0 ds/m and 16.3 ds/m salt stress in lentil

S.No.	Genotype	Selection attribute	Germination %		Plumule/radicle ratio	
			0 ds/m	16.3 ds/m	0 ds/m	16.3 ds/m
		* Ratio > 1				
1)	DGL-63		97	70	1.15	1.24
2)	DGL-169		93	55	1.14	1.15
3)	L-683/83		95	64	1.30	1.06
		Better germination				
4)	DLG-72		94	71	1.46	0.92
5)	DLG-97		91	76	1.28	0.88
6)	L-201/83		96	68	1.17	1.03

The preliminary investigations under this study revealed that out of germination and other seedling traits, any one character exclusively can not become a selection criteria rather germination along with the plumule radicle ratio can be combined to get a possible generalisation under salt stress in lentil.

Further studies on ion accumulations have been conducted on selected genotypes on the basis of above mentioned criteria under glasshouse conditions. The results will be presented in the next paper.

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CHARACTERIZATION OF GENETIC RESOURCES OF INDIAN MUSTARD

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Evaluation of 360 indigenous accessions of Indian mustard (*Brassica juncea* L. Czern. & Coss.) for yield contributing traits and oil content indicated an appreciable range of variation. Secondary branches/plant, 1000 seed-weight and primary branches/plant had high variability (CV.20.8-32.3%). Oil content varied the least (CV.3.3%). Except for days to maturity and plant height, the remaining traits exhibited moderate variation. Several useful accessions for various morpho-agronomic characters and oil content were identified which can be utilized in the breeding programme to improve seed and oil yield.

Key words : Genetic resources, morpho-agronomic characters, oil content, oil-seeds, Indian mustard, *Brassica juncea*

Indian mustard is second important oilseeds crop of India after groundnut. There has been a phenomenal growth in mustard production and productivity during the last 10 years. It accounts for 13 per cent of the country's gross cropped area and 30 per cent of the total oilseeds production. It is a major source of edible oil in Indian diet besides its oilcake serving as livestock feed and a major source to earn foreign exchange. Efforts have been made to evaluate, characterize, preserve and catalogue the genetic resources of rapeseed-mustard (Anon., 1983; Kumar, 1987 and Kumar and Singh 1978). Improvement of seed and oil yield in this crop to meet the increasing demand of oil is foremost. Therefore, there is a need to intensify efforts to search for appropriate donors for utilization in the breeding programme. In the present paper, attempts have been made to characterize the genetic resources of Indian mustard maintained at this Centre to assess their potential use in cultivar development programme.

MATERIALS AND METHODS

Three hundred and sixty accessions of Indian mustard (*Brassica juncea* L. Czren. & Coss.) were sown in augmented design during rabi 1995-96 season at National Research Centre on Rapeseed-Mustard, Bharatpur. The accessions were grown in 2 rows (0.4g/m²) of 5m length with plant-to-plant and row-to-row

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spacings of 15 and 30 cm, respectively. Forty Kg N and full dose of phosphorus were applied at the time of sowing while remaining 40 kg of nitrogen was top-dressed just after irrigation (40 days after sowing). Standard agronomic practices were followed and plant protection measures were adopted as and when required.

Observations were recorded on 5 competitive randomly selected plants for days to maturity, plant height (cm), primary branches per plant (No.), secondary branches per plant (No.), main shoot length (cm), siliqua per main shoot (No.), siliqua length (cm), seeds per siliqua (No.), 1000-seed weight (g) and oil content (%). Seed counting of 1000 seeds was done by an electronic seed counter ("L" Systems, Old mill Co., USA) and weighed and the oil content was analysed by nuclear magnetic resonance (Oxford 5000).

RESULTS AND DISCUSSION

All the characters except days to maturity, plant height and oil content exhibited considerable variability in the collections investigated (Table 1). Plant height and maturity are the two important varietal traits determining its suitability in a production system. Varieties with shorter height and early maturity are the preferred ones. Plant height in the present collections ranged from 89.2 cm (JMG 110) to 227 cm (JMG 73). This character, however, showed low variability. Most of the accessions (82.2%) had the plant height varying from 150 to 200 cm. (Fig. 1A). Nevertheless, about 16.1 per cent of the accessions showed more than 200 cm plant height. Majority of the accessions (72.3%) took 121-135 days to mature, (Fig. 1B) but maturity varied from 118 (JMG 151) to 143 days (WRR 3-1). Seventy-seven accessions were of early

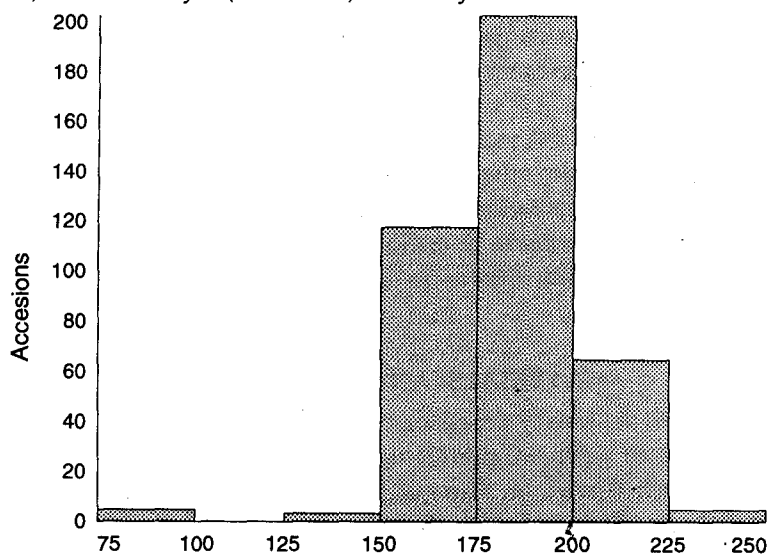


Fig. 1A : Plant height (cm)

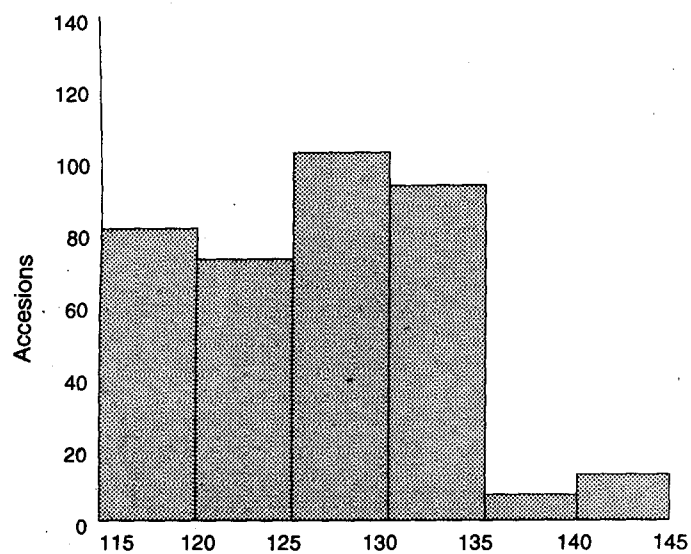


Fig. 1B : Maturity (days)

maturity (120 days). Only 22 were late maturing type (> 135 days). This character had low variability (Table 1).

Table 1. Range, mean and coefficient of variation (%) for various morpho-agronomic traits and oil content in Indian mustard

Character	Range	Mean $\pm$ SEM	Coefficient of variation (%)
Days to maturity	118-143 (JMG 151) (WRR 3-1)	126.9 $\pm$ 0.3	4.9
Plant height (cm)	89.2-227.0 (JMG 110) (JMG 73)	183.2 $\pm$ 0.9	9.34
Primary branches/plant (No.)	4.0-14.0 (JM 162) (JMG 39)	7.8 $\pm$ 0.86	20.8
Secondary branches/plant (No.)	4.4-25.8 (CSR 117) (JMG 127)	11.9 $\pm$ 0.2	32.3
Main shoot length (cm)	37.0-112.4 (CSR 128) (JMG 236)	82.7 $\pm$ 0.6	12.6
Siliquae main shoot (No.)	28.4-82.2 (CSR 102) (JMG 109)	43.7 $\pm$ 0.4	16.4
Silique length (cm)	3.2-5.8 (JMG 160) (JMG 63)	4.2 $\pm$ 0.02	10.3
Seeds/silique (no)	9.8-23.8 (JMG 196) (JMG 63)	14.0 $\pm$ 0.1	15.5
Seed weight (g)	2.26-7.87 (JMG 211) (JMG 151)	4.8 $\pm$ 0.06	24.5
Oil content (%)	35.0-42.9 (CSR 46) (JMG 78)	39.1 $\pm$ 0.10	3.0

Main shoot length had moderate variation (CV. 12.6%) in the present collection. The accession CSR 128 had the shortest main shoot (37 cm), whereas JMG 236, the longest (112.4 cm). About 61 per cent of the accessions had main shoot length in the range of 71 to 90 cm (Fig. 1C). Number of primary

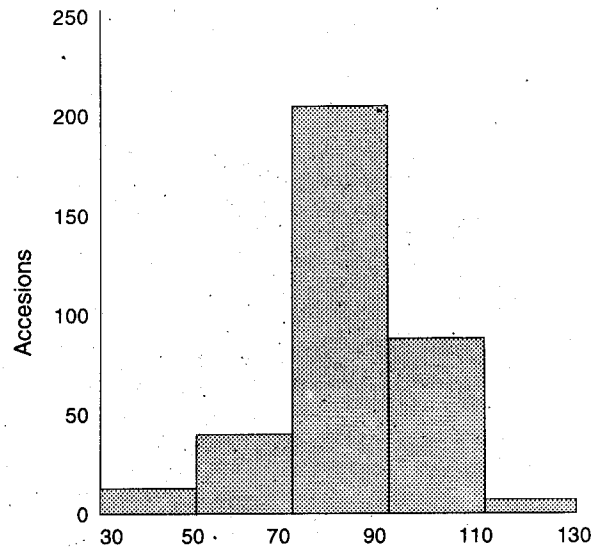


Fig. 1C : Main shoot length (cm)

and secondary branches per plant are the major seed yield contributors in this crop. The secondary branches per plant varied the most (CV. 32.5%). Primary branches per plant also exhibited appreciable variation (CV. 20.8%). In majority of the accessions (78%), primary branches ranged from, 6.1 to 10, only 1.7 per cent had the highest number of primary branches (> 12) (Fig. 1D). Accession JMG 127 had the maximum secondary branches per plant and the mean was 11.93 ± 0.21 . Eleven accessions (3.1%) had very high (20-24) number of secondary branches (Fig. 1E). Variability for siliquae on main shoot was moderate (Table 1) and ranged from 28 (CSR 102) to 82 (JMG 109) with an average of 43.7 ± 0.38 . Most of the accessions (63.9%) had a range of 40 to 60 (Fig. 1F). The coefficients of variation for siliqua length and seeds per siliqua suggested moderate variation (Table 1). The maximum and minimum siliqua length was recorded in the accession JMG 63 (5.8 cm) and JMG 160 (3.2 cm). In general, siliqua length varied from 4.1 to 5.0 cm (207 accessions). Seeds per siliqua ranged from 10 (JMG 196) to 24 (JMG 63). This character had narrow range of variation (10-15) in 77.8% of the accessions (Fig. 1H). Three accessions had more than 20 seeds per siliqua (Fig. 1I). Seed weight is an important character in determining seed yield. Therefore, developing bold-seeded varieties is the foremost in the mustard cultivar development programme. Hence, identification of suitable donors with high seed weight is quite imperative. The present collections exhibited high variability for this trait

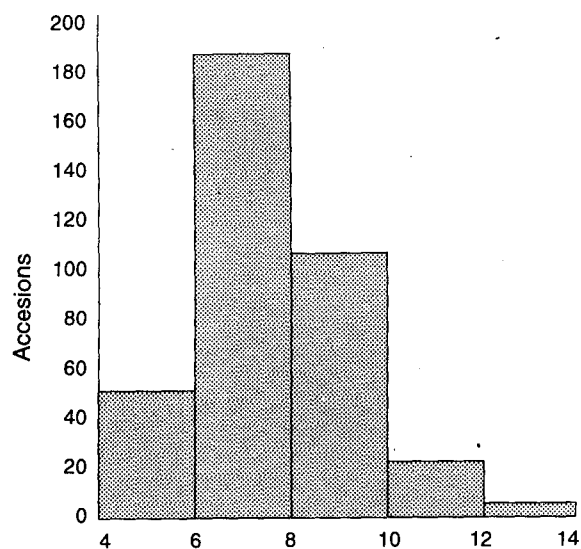


Fig. 1D : Primary branches/plant

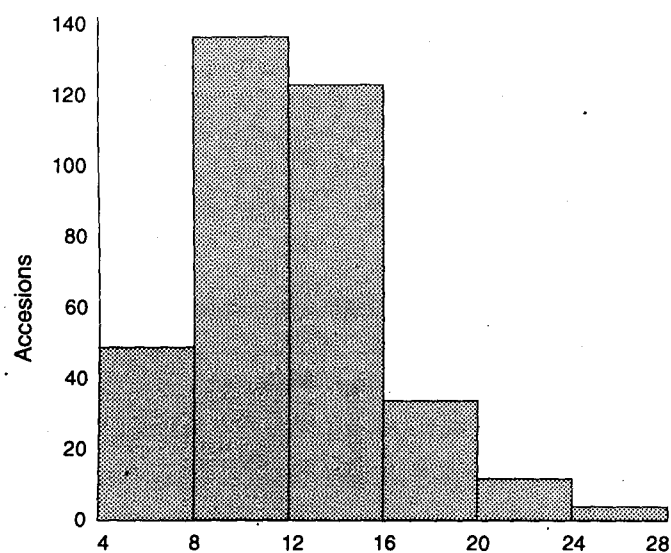
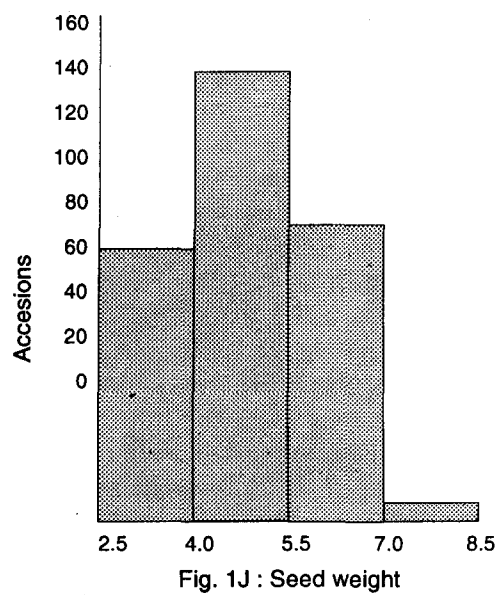
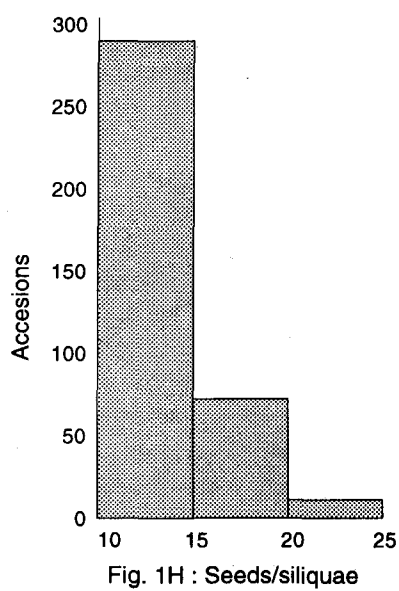
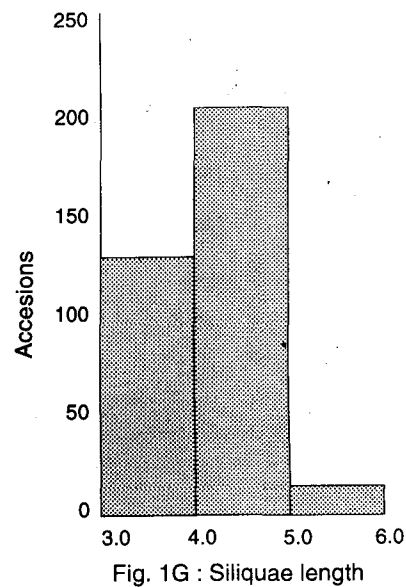
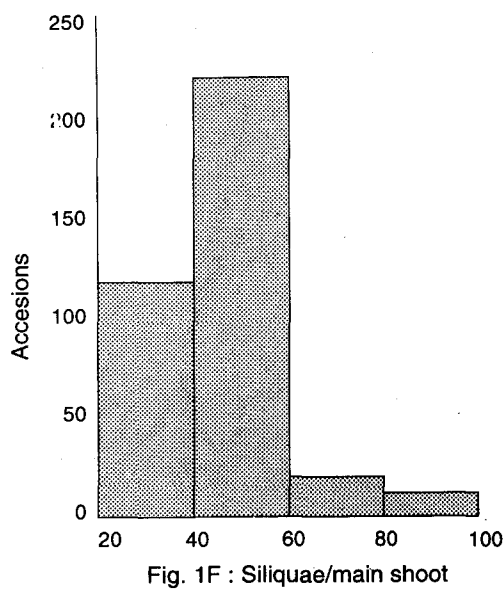


Fig. 1E : Secondary branches/plant

(CV. 24.5%). The range and mean were 2.26 (JMG 211) to 7.87 (JMG 151) and 8.4 ± 0.06 , respectively. Thirteen of the 360 accessions could be the potential donors for high seed weight (> 7.0 g; Fig. 1J). The accessions showed the least variation (CVI. 3.3%) for oil content, although it varied from 35.0 (CSR 46) to 42.5% (JMG 78) of the three hundred sixty accessions, 319 (88.6%) exhibited a range of 37 to 41 per cent and only 23 (6.4%) had oil content $>$



41% (Fig. 1K). Similar pattern in respect of oil has been observed earlier (Anonymous, 1983).

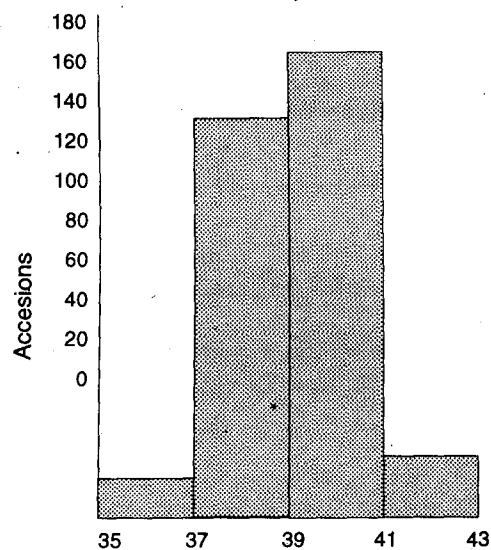


Fig. 1K : Oil content (%)

The present collections proved to be an important gene pool for different morpho-agronomic characters and many accessions (Table 2) could be utilized for rational hybridization programme to improve seed yield. Besides seed yield, oil yield determines the commercial success of a variety. Thus development of improved germplasm with high oil content remains the top priority of

Table 2. Donors for various morpho-agronomic characters in Indian mustard

Characters	Donors Accessions
Plant height (< 155 cm)	JMG 110, BACR 50, JMG 248, CSR 128, JMG 365
Primary branches/plant (≥ 12 cm)	JMG 39, B 29, CSR 57, JMG 122, CSR 156
Secondary branches/(Plant (≥ 18 cm)	JMG 127, JMG 105, JMG 226, JMG 88, B 48
Main shoot length (≥ 99 cm)	JMG 236, CSR 72, CSR 14, JMG 226, CSR 50
Siliquae main shoot (≥ 62 cm)	JMG 109, JMG 239, JMG 236, JMG 161, JMG 386
Siliqua length (≥ 5.4 cm)	JMG 63, JMG 79, JMG 64, JMG 117, JMG 67
Seeds/siliqua (≥ 20)	JMG 63, JMG 74, JMG 68, JMG 64, CSR 147
1000 seed weight (≥ 7.5 g)	JMG 151, CSR 64, JMG 238, JMG 369, JMG 98

breeders. Ten top high oil yielding accessions alongwith their morpho-agronomic characters have been identified (Table 3).

Table 3. Characterization of high oil content accessions of Indian mustard

Accession	Oil content (%)	Days to maturity	Plant height (cm)	Primary branches/ plant (No.)	Secondary branches/ plant (No.)	Siliquae main shoot (No.)	Siliqua length (cm)	Seeds/ siliqua (No.)	Seed weight (g)
JMG 78	42.9	179	170	5	38	38	4.5	15	5.9
JMG 88	42.8	119	166	23	41	41	5.0	13	4.9
CSR 156	42.3	132	221	13	56	56	3.3	12	4.7
JMG 221	42.2	116	181	22	52	52	4.6	15	3.0
JMG 237	42.1	119	173	14	41	41	4.1	13	3.4
JMG 279	41.7	126	204	8	49	49	4.2	13	4.3
JMG 19	41.6	119	168	10	47	47	3.9	13	6.0
JMG 211	41.6	117	187	12	40	40	3.7	15	2.3
JMG 96	41.5	118	173	16	44	44	4.5	16	5.9
JMG 282	41.4	123	167	11	39	39	4.0	13	3.1

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VARIABILITY, CHARACTER ASSOCIATIONS AND SELECTION OF PARENTS IN GENETICALLY DIVERSE POPULATIONS OF SUGARCANE UNDER CONDITIONS OF NORTH WESTERN ZONE

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With an objective to identify new donors for different characters from genetically diverse material involving various *Saccharum* species, forty hybrids each during 1990-91 (set-I), 1991-92 (set-II) and 1992-93 (set-III) cropping seasons were evaluated. Correlations among stalk yield and its components showed that number of millable stalks (NMS) and stalk length were positively associated with stalk yield in all three sets whereas with sugar yield, stalk yield in all three sets and quality traits in set-II and set-III were positively associated. Path analysis revealed the importance of NMS in all three sets, stalk length in set-II and single stalk weight (SSW) in set-III for increasing stalk yield. For sugar yield, NMS in set-I, brix and CCS per cent in set-II, sucrose per cent and SSW in set-III would prove reliable. Twenty six elite clones combining stalk yield and juice quality attributes were identified. Apart from these, donors for seven individual traits of yield and quality and red rot resistance were also identified. Utilization of selected clones in combination with proven parents/commercial hybrids is suggested.

Key words : Variability, correlation and path analyses, selection, interspecific hybrids, *Saccharum* spp.

The use of interspecific hybridization in sugarcane breeding has enabled the successful incorporation of vigour and disease resistance from wild species into the high sucrose clones of *S. officinarum*. Despite the broad extent of successful interspecific and intergeneric hybridization with *Saccharum*, relatively few clones of wild species occur in the pedigree of modern sugarcane cultivars and the progress in improvement of commercially cultivated varieties has been achieved almost entirely with a germplasm base which is now five to seven decades old. However, there have been some awareness of limited genetic base of modern hybrids and a realisation that naturally occurring forms of *Saccharum* may have good chances to contribute much more. Consequently, the need for a new cycle of nobilization using diverse clones of *S. officinarum*, *S. spontaneum*, *S. sinense*, *S. barberi* and *S. robustum* has been suggested by many workers (Walker, 1972; Ethiraja, 1987; Heinz, 1987; Rao, 1987) in order to broaden the genetic base in sugarcane. Considering these observations a

programme on utilization of *Saccharum* species clones was initiated at Sugarcane Breeding Institute, Coimbatore during early nineties. The selected material was sent to four locations, including Karnal, representing different zones of sugarcane for further evaluation under local conditions and identification of elite donors for different zones. The present investigation aims to estimate variability, correlation and direct and indirect relationships between various yield and quality attributes and their relative impact on stalk and sugar yield to identify important character associations for selecting donors suitable for North Western Zone for further use in breeding.

MATERIALS AND METHODS

The experimental materials comprised of hybrid progenies from crosses involving commercial hybrids, *S. officinarum*, *S. barberi*, *S. sinense*, *S. spontaneum* and *S. robustum*. Forty hybrids each during 1990-91 (set-I), 1991-92 (set-II) and 1992-93 (set-III) seasons (Table 1) were evaluated in randomised block designs with two replications. Each hybrid was grown in a three row plot, 6m long, spaced 85 cm apart. Twenty four three-budded setts were planted in a row at equal distance. The trials were harvested after 360 days and data on twelve quantitative characters were recorded. Statistical analyses were done following standard procedures. The significance of phenotypic correlation coefficients was tested as per Fisher and Yates (1967).

Table 1. Details of hybrids evaluated in 3 trials during 1990-93

Pedigree	No. of hybrids evaluated during		
	1990-91	1991-92	1992-93
OR	-	2	2
(OR)H	2	23	9
(HR)H	4	3	7
[(OR)H]H	3	4	1
(OR) (OR)	3	1	1
(HR) (HR)	1	-	-
HO	6	1	9
HS	13	5	-
OS	-	-	2
HB	8	1	2
OB	-	-	7
Total	40	40	40

O : *S. officinarum*

R : *S. robustum*

H : Commercial hybrids

S : *S. spontaneum*

B : *S. barberi/sinense*

RESULTS AND DISCUSSION

The analysis of variance showed significant differences among ISH clones for all the characters studied in three sets. The genotypic coefficient of variation (GCV) gives the plant breeder perspective of the variability to be potentially exploited for genetic gain. The GCV was higher for number of millable stalks (NMS), stalk and sugar yields and single stalk weight (SSW) in comparison with stalk diameter, stalk length and all quality traits (Table 2). This indicated the better chances of success in selection programme based on NMS, stalk and sugar yields and SSW. Among the quality traits, GCV was higher for CCS% and sucrose % thereby indicating the better chances of selection based on these traits to identify high quality clones. The effect of high GCV for NMS, stalk and sugar yields and SSW was reflected in higher expected genetic advance for these traits. The heritability values were the maximum for NMS followed by fiber %, stalk diameter, stalk yield, and quality traits.

Table 2. Mean, genotypic coefficient of variation (GCV), heritability (h^2) and expected genetic advance expressed as % of mean (GA) in three populations of sugarcane

Character	Set	Mean	GCV	h^2	GA
Number of millable stalks/ plot (NMS)	I	169.25	47.61	0.96	96.13
	II	73.95	40.65	0.85	77.11
	III	117.71	24.84	0.56	38.45
Stalk diameter (cm)	I	2.12	16.42	0.84	30.92
	II	2.22	11.84	0.68	20.15
	III	2.40	14.08	0.85	26.70
Stalk length (cm)	I	202.21	8.65	0.32	10.01
	II	207.89	8.64	0.41	14.41
	III	243.00	6.28	0.42	8.43
Single stalk weight (kg) (SSW)	I	0.96	24.96	0.58	39.23
	II	0.90	25.58	0.58	40.30
	III	1.22	26.81	0.81	49.71
Juice extraction %	I	48.82	10.09	0.58	15.79
	II	48.40	5.11	0.24	5.13
	II	51.73	6.46	0.48	9.22
Fibre %	I	14.63	21.29	0.88	41.10
	II	14.97	17.72	0.83	33.27
	III	12.81	11.74	0.93	23.31

Brix %	I	20.15	7.17	0.60	11.49
	II	21.35	6.38	0.67	10.80
	III	19.81	8.47	0.74	15.06
Sucrose %	I	16.56	12.37	0.74	21.86
	II	18.54	9.32	0.67	15.72
	III	17.22	12.14	0.79	22.17
Purity %	I	82.28	6.04	0.75	10.77
	II	86.63	3.48	0.60	5.57
	III	86.51	5.06	0.80	9.32
CCS %	I	11.08	15.21	0.75	27.18
	II	12.71	10.79	0.66	18.08
	III	11.82	14.06	0.79	25.77
Stalk yield/plot (kg)	I	42.68	38.10	0.80	70.41
	II	58.56	24.82	0.67	41.78
	III	84.41	28.91	0.75	51.65
Sugar yield/plot (kg)	I	4.58	30.09	0.63	49.30
	II	7.50	27.94	0.64	46.18
	III	10.04	32.99	0.75	58.98

The interrelationships among stalk yield and its components (Table 3) showed that NMS and stalk length were positively associated with stalk yield in all three sets. Stalk diameter, SSW, juice extraction, sucrose, purity and CCS showed negative association with stalk yield whereas the correlation between fibre % and stalk yield was significant and positive only in set-I. In set-III, SSW was associated positively with stalk yield. Rest of associations of characters with stalk yield were non-significant.

Among the component characters of stalk yield NMS showed negative associations with SSW whereas the correlation between NMS and fibre % was positive in all the sets. Relationships of stalk diameter with SSW in all sets and juice extraction in sets I and III were positive whereas it was negatively associated with fibre%. Stalk length showed positive association with SSW in sets II and III and fibre in sets I and II but the association was negative with juice extraction only in set-I. Correlations between SSW and juice extraction were significant and positive in sets I and III whereas SSW was negatively associated with fibre in three sets. As expected, the association between juice extraction percent and fibre percent were negative but were significant in sets I and II. Thus, for improving stalk yield, genotypes with high NMS and SSW should be selected but stalk diameter has to be given due importance.

Table 3. Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients among yield and quality traits in three sets of sugarcane

Character	Set	NMS	Stalk diam.	Stalk length	SSW	Juice extr. %	Fibre %	Brix %	Sucrose %	Purity %	CCS%	Stalk yield	Sugar yield
NMS	I	—	-0.77**	0.47**	-0.58**	-0.60**	-0.66**	-0.54**	-0.66**	-0.70**	-0.67**	0.84**	0.51**
	II	—	-0.75**	0.15	-0.58**	-0.25	0.66**	-0.43**	-0.50**	-0.60**	-0.52**	0.32*	0.09
	III	—	-0.47**	0.10	-0.37*	-0.35*	0.57**	-0.30	-0.34*	-0.35*	-0.35*	0.40**	0.20
Stalk diameter	I	-0.86	—	-0.17	0.88**	0.70**	-0.67**	0.51**	0.60**	0.62**	0.61**	-0.57**	-0.25
	II	-0.98	—	0.13	0.74**	0.23	-0.57**	0.55**	0.63**	0.70**	0.64**	0.04	0.25
	III	-0.69	—	0.14	0.89**	0.61**	-0.43**	0.42**	0.47**	0.50**	0.48**	0.25	0.40**
Stalk length	I	0.88	-0.64	—	0.24	-0.31*	0.38*	-0.40**	-0.45**	-0.45**	-0.45**	0.47**	0.23
	II	0.21	-0.08	—	0.39*	-0.12	0.31*	0.19	0.18	0.14	0.17	0.59**	0.55**
	III	-0.09	0.27	—	0.47**	0.01	0.06	-0.15	-0.12	-0.02	-0.11	0.40**	0.31*
SSW	I	-0.75	0.98	-0.49	—	0.52**	-0.48**	0.36*	0.42**	0.42**	0.42**	0.43**	-0.35*
	II	-0.85	0.97	0.01	—	0.23	-0.43**	0.52**	0.56**	0.57**	0.56**	0.24	0.41**
	III	-0.60	0.95	0.53	—	0.53**	-0.31*	0.35*	0.39*	0.41**	0.40**	0.42**	0.52**
Juice extr. %	I	-0.77	0.90	-0.77	0.85	—	-0.72**	0.42**	0.53**	0.57**	0.54**	-0.48**	-0.19
	II	-0.64	0.34	-1.06	0.26	—	-0.46**	0.14	0.18	0.23	0.19	-0.09	0.01
	III	-0.8	0.80	0.03	0.79	—	-0.20	0.46**	0.46**	0.33*	0.45**	0.16	0.31*

(Contd. on next page)

Character	Set	NMS	Stalk diam.	Stalk length	SSW	Juice extr. %	Fibre %	Brix %	Sucrose %	Purity %	CCS%	Stalk yield	Sugar yield
Fibre %	I	0.72	-0.77	0.64	-0.68	-0.87	—	-0.41**	-0.54**	-0.61**	-0.56**	0.56**	0.26
	II	0.79	-0.79	0.54	-0.58	-1.02	—	-0.25	-0.32*	-0.42**	-0.34*	0.22	0.06
	III	0.78	-0.45	0.05	-0.32	-0.29	—	-0.21	-0.21	-0.19	-0.20	0.18	0.07
Brix %	I	-0.71	0.72	-0.40	0.74	0.80	-0.63	—	0.93**	0.64**	0.89**	-0.28	0.19
	II	-0.55	0.73	0.08	0.71	-0.09	-0.31	—	0.97**	0.83**	0.96**	0.27	0.57**
	III	-0.48	0.43	-0.12	0.38	0.53	-0.19	—	0.97**	0.69**	0.94**	0.13	0.50**
Sucrose %	I	-0.79	0.80	-0.57	0.78	0.85	-0.69	0.96	—	0.87**	0.99**	-0.40**	0.11
	II	-0.64	0.83	0.03	0.76	-0.05	-0.41	0.98	—	0.92**	0.99**	0.23	0.56**
	III	-0.52	0.51	-0.03	0.45	0.54	-0.20	0.98	—	0.85**	0.99**	0.11	0.51**
Purity %	I	-0.83	-0.83	-0.78	0.74	0.84	-0.71	0.83	0.94	—	0.91**	-0.52**	-0.05
	II	-0.82	0.99	-0.05	0.81	0.05	-0.59	0.92	0.96	—	0.94**	0.15	0.47**
	III	-0.58	0.60	-0.09	0.50	0.47	-0.21	0.76	0.88	—	0.88**	0.05	0.40**
CCS%	I	-0.79	0.81	-0.61	0.77	0.85	-0.70	0.95	0.99	0.96	—	-0.42**	0.09
	II	-0.67	0.86	0.02	0.77	-0.04	-0.44	0.98	0.99	0.97	—	0.22	0.56**
	III	-0.52	0.53	-0.01	0.46	0.54	-0.20	0.96	0.99	0.91	—	0.11	0.50**

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Character	Set	NMS	Stalk diam.	Stalk length	SSW	Juice extr. %	Fibre %	Brix %	Sucrose %	Purity %	CCS%	Stalk yield	Sugar yield
Stalk yield	I	0.90	-0.65	0.93	-0.49	-0.67	0.67	-0.43	-0.57	-0.72	-0.59	—	0.85**
	II	0.31	0.06	0.79	0.21	-0.62	0.39	0.28	0.25	0.15	0.24	—	0.93**
	III	0.40	0.29	0.46	0.48	0.12	0.22	0.10	0.11	0.06	0.11	—	0.90**
Sugar yield	I	0.58	-0.26	0.69	-0.11	-0.27	0.36	0.09	-0.06	-0.28	-0.09	0.85	—
	II	0.02	0.34	0.65	0.45	-0.58	0.18	0.60	0.57	0.47	0.56	0.93	—
	III	0.14	0.44	0.44	0.60	0.30	0.09	0.51	0.52	0.42	0.51	0.90	—

*, ** Significant at $p = 0.05$ and 0.01 , respectively.

The association between sugar yield and other traits also varied in three sets (Table 3). High positive correlation coefficients were observed between stalk yield and sugar yield in all sets. Quality traits showed significant positive relationship with sugar yield only in sets II and III. Among the component traits of stalk yield, NMS in set I, stalk diameter in set III, stalk length and SSW in sets II and III were positively correlated with sugar yield. Therefore, sugar yield could be improved by increasing stalk yield however, maintaining sucrose percent at economic threshold level.

The interrelationships between component characters of stalk yield and quality parameters varied among three sets. NMS (in three sets), fibre percent (sets I and III) showed negative associations with quality parameters. The inverse relationships between NMS and quality traits indicate that the photosynthetic assimilates are mainly utilised for production and growth of stalks rather than storage of sugars in the stalks in these genotypes with high NMS (see Table 2). Quality traits were positively correlated with stalk diameter, SSW (in three sets) and juice extraction (sets I and III) indicating their importance for better quality genotypes, however, maintaining NMS at moderate level. Similarly, Bakshi Ram and Hemaprabha (1991) also reported importance of stalk diameter and SSW for selecting high quality genotypes among commercial hybrids $\times$ *S. spontaneum* progenies. Association between stalk length and quality traits varied from low positive in set II to significant negative in set I.

On the basis of results obtained from path analysis (Table 4), NMS was found to have moderate to high direct effects on stalk yield thereby suggesting the importance of NMS for improving stalk yield in all sets. Similarly, stalk length in set II and SSW in set III were important traits of stalk yield. On the contrary negative correlation and direct effects were observed for sucrose and purity in set I. Fibre content with low direct effect in three sets was not an important character of stalk yield. Wide variations were observed between the two values for other character associations. Correlation coefficients were positive and much higher than direct effects for stalk length in set I and III and fibre content in set I. High correlation coefficient between stalk length and stalk yield was mainly due to its higher indirect effect through NMS in set I whereas due to its higher positive indirect effects through SSW, brix % and CCS % in set III.

Path analysis for sugar yield revealed wide variations between significant correlation coefficients and direct effects for most of character associations excepting SSW in set III and brix % in set II (Table 5). This indicated the importance of indirect effects. The role of indirect effects on correlation values were remarkable for NMS in set I, CCS content in set II and sucrose content in set III. In such situations, the indirect casual factors are to be considered simultaneously for selection to increase efficiency of selection. Even though

Table 4. Phenotypic path coefficient analysis of stalk yield and other traits in three sets of sugarcane

Character	Set	NMS	Stalk diam.	Stalk length	SSW	Juice extr%	Fibre %	Brix %	Sucr. %	Purity %	CCS %	Corr. with st. yield
NMS	I	1.07	0.16	-0.04	-0.23	0.00	0.05	-0.29	0.28	-0.19	0.03	0.84**
	II	0.71	-0.08	0.05	-0.12	0.02	-0.09	-0.44	1.45	-0.16	-1.03	0.32*
	III	0.66	0.10	0.00	-0.29	-0.01	-0.02	0.75	-1.68	0.23	0.66	0.40**
Stalk diameter	I	-0.83	-0.20	0.01	0.35	0.00	-0.05	0.27	-0.25	0.17	-0.03	-0.57**
	II	-0.53	0.11	0.05	0.15	-0.02	0.08	0.57	-1.82	0.17	1.27	0.04
	III	-0.31	-0.20	0.00	0.71	0.02	0.01	-1.06	0.69	-0.33	-0.27	0.25
Stalk	I	0.51	0.04	-0.08	0.10	0.00	0.03	-0.21	0.19	-0.12	0.02	0.47**
	II	0.11	0.01	0.37	0.08	0.01	-0.04	0.19	-0.52	0.04	0.35	0.59**
	III	0.06	-0.03	0.01	0.38	0.00	-0.00	0.38	-0.91	0.01	0.50	0.40**
SSW	I	-0.62	-0.18	-0.02	0.40	-0.00	-0.03	0.19	-0.18	0.12	-0.02	-0.35*
	II	-0.41	0.08	0.14	0.21	-0.02	0.06	0.54	-0.62	0.14	1.12	0.24
	III	-0.24	-0.18	0.00	0.79	0.01	0.01	-0.89	2.05	-0.27	-0.86	0.42**
Juice extr. %	I	-0.64	-0.14	0.02	0.20	-0.00	-0.05	0.22	-0.22	0.16	-0.03	-0.48**
	II	-0.18	0.03	-0.05	0.05	-0.07	0.07	0.14	-0.52	0.06	0.38	-0.09
	III	-0.23	-0.12	0.00	0.42	0.03	0.01	-1.18	2.55	-0.21	-1.10	0.16
Fibre %	I	0.70	0.13	-0.03	-0.19	0.00	0.07	-0.22	0.23	-0.17	0.03	0.56**
	II	0.47	-0.06	0.12	-0.09	0.03	-0.14	-0.26	0.93	-0.10	-0.67	0.22
	III	0.37	0.09	0.00	-0.25	-0.01	-0.03	0.53	-1.61	0.13	0.95	0.18

(Contd. on next page)

Character	Set	NMS	Stalk diam.	Stalk length	SSW	Juice extr%	Fibre %	Brix %	Sucr. %	Purity %	CCS %	Corr. with st. yield
Brix %	I	-0.58	-0.10	0.03	0.14	-0.00	-0.03	0.53	-0.39	0.18	-0.06	-0.28
	II	-0.30	0.06	0.07	0.11	-0.01	0.04	1.03	-1.84	0.20	0.90	0.26
	III	-0.19	-0.08	-0.00	0.28	0.01	0.01	-0.55	2.53	-0.45	-1.43	0.13
Sucrose %	I	-0.70	-0.12	0.04	0.17	-0.00	-0.04	0.49	-0.42	0.24	-0.05	-0.40**
	II	-0.36	0.07	0.07	0.12	-0.01	0.05	1.00	-0.91	0.23	0.98	0.23
	III	-0.23	-0.10	-0.00	0.31	0.01	0.01	-0.46	1.80	-0.55	-0.68	0.11
Purity %	I	-0.75	-0.12	0.04	0.17	-0.00	-0.06	0.34	-0.37	0.28	-0.04	-0.52**
	II	-0.42	0.08	0.05	0.12	-0.02	0.06	0.85	-1.68	0.25	0.87	0.15
	III	-0.23	-0.10	-0.00	0.33	0.01	0.01	-0.77	2.61	-0.65	-0.15	0.05
CCS %	I	-0.72	-0.12	0.04	0.17	-0.00	-0.04	0.47	-0.42	0.25	-0.05	-0.42**
	II	-0.37	0.07	0.06	0.12	-0.01	0.05	0.99	-0.90	0.23	0.98	0.22
	III	-0.23	-0.10	-0.00	0.31	0.01	0.01	-1.40	2.77	-0.58	-0.69	0.11
Residual	I	0.22										
	II	0.45										
	III	0.43										

* , ** Significant at P = 0.05 and 0.01, respectively.

the direct effects of NMS in set I, CCS in set II and sucrose % in set III were brought down, higher direct effects of NMS in set I, CCS percent and brix content in set II, sucrose % and SSW in set III on sugar yield would prove reliable for commercialisation of these early interspecific hybrids through breeding and selection.

Table 5. Phenotypic path coefficient analysis of sugar yield and other traits in three sets of sugarcane

Char- acter	Set	NMS	Stalk diam.	Stalk length	SSW	Juice extr.%	Fibre %	Brix %	Sucr. %	Pur- ity %	CCS %	Corr. with sug. yield
NMS	I	1.21	0.26	-0.08	-0.34	-0.01	0.04	-0.86	0.92	-0.85	0.21	0.51**
	II	0.59	-0.03	0.04	-0.12	0.01	-0.08	-0.14	0.65	0.01	-0.84	0.09
	III	0.55	0.08	0.00	-0.24	-0.01	-0.02	0.75	-0.81	0.21	0.68	0.20
Stalk dia- meter	I	-0.94	-0.34	0.03	0.51	0.01	-0.04	0.80	-0.84	0.75	-0.19	-0.25
	II	-0.44	0.04	0.04	0.16	-0.01	0.07	0.18	-0.81	-0.01	1.04	0.25
	III	-0.26	-0.18	0.01	0.58	0.01	0.01	-0.77	2.32	-0.30	-0.03	0.40**
Stalk length	I	0.57	0.06	-0.16	0.14	-0.01	0.02	-0.62	0.63	-0.55	0.14	0.23
	II	0.09	0.00	0.29	0.09	0.00	-0.04	0.06	-0.23	-0.00	0.28	0.55**
	III	0.05	-0.02	0.04	0.31	0.00	-0.00	0.63	-1.80	0.01	1.09	0.31*
SSW	I	-0.70	-0.30	-0.04	0.59	0.01	-0.03	0.56	-0.59	0.51	-0.14	-0.12
	II	-0.34	0.03	0.11	0.21	-0.01	0.05	0.18	-0.72	-0.01	0.91	0.41**
	III	-0.20	-0.16	0.02	0.65	0.01	0.01	-0.47	2.02	-0.25	-0.12	0.52**
Juice extr.%	I	-0.73	-0.24	0.05	0.30	0.02	-0.04	0.67	-0.73	0.69	-0.17	-0.19
	II	-0.15	0.01	-0.04	0.05	-0.03	0.05	0.05	0.04	-0.23	-0.00	0.31
	III	-0.19	-0.11	0.00	0.35	0.02	0.01	-0.97	2.04	-0.20	-0.65	0.31*
Fibre %	I	0.79	0.23	-0.06	-0.28	-0.01	0.06	-0.65	0.75	-0.75	0.18	0.26
	II	0.39	-0.02	0.09	-0.09	0.21	-0.12	-0.08	0.41	0.01	-0.54	0.06
	III	0.31	0.07	0.00	-0.20	-0.00	-0.03	0.88	-2.19	0.12	1.10	0.07
Brix %	I	-0.66	-0.17	0.06	0.21	0.01	-0.03	1.58	-1.30	0.77	-0.28	0.19
	II	-0.25	0.02	0.05	0.11	-0.01	0.03	0.33	-1.26	-0.01	1.55	0.57**
	III	-0.16	-0.07	-0.01	0.23	0.01	0.01	-1.24	2.95	-0.42	-0.80	0.50**

Suc- rose %	I	-0.80	-0.20	0.07	0.25	0.01	-0.03	1.48	-1.39	1.03	-0.31	0.11
	II	-0.30	0.02	0.05	0.12	-0.01	0.04	0.33	-1.29	-0.01	1.61	0.56**
	III	-0.19	-0.08	-0.00	0.25	0.01	0.01	-1.09	3.47	-0.51	-1.36	0.51**
Purity %	I	-0.85	-0.21	0.07	0.24	0.01	-0.04	1.00	-1.20	1.21	-0.29	-0.05
	II	-0.35	0.03	0.03	0.12	-0.01	0.05	0.28	-1.19	-0.01	1.52	0.47**
	III	-0.19	-0.09	-0.00	0.27	0.01	0.01	-0.94	3.12	-0.60	-1.18	0.40**
CCS %	I	-0.81	-0.21	0.07	0.25	0.01	-0.04	1.41	-1.39	1.11	-0.32	0.09
	II	-0.31	0.02	0.05	0.12	-0.01	0.04	0.32	-1.28	-0.01	1.61	0.56**
	III	-0.20	-0.08	-0.00	0.26	0.01	0.01	-1.00	3.43	-0.53	-1.39	0.50**
Resi- dual	I	0.33										
	II	0.34										
	III	0.33										

*, ** Significant at $p=0.05$ and 0.01 , respectively.

In their studies, Bakshi Ram and Hemaprabha (1991, 1992) also emphasised the importance of different traits in different mating groups involving various *Saccharum* species. In the present study, the experimental material in three sets was comprised of hybrids involving different species of *Saccharum* and hence may be the cause of variation in the effective component together with deviation in interrelationships between the component characters. Another reason may be the retention of the original species associations as reported by Brown *et al.* (1969). In this regard, the realistic relationship between the characters in these interspecific hybrids can act as a valuable aid in enhancing the efficiency of selection in sugarcane breeding aimed at maximising sugar productivity.

Fibre content with very low direct effects on stalk yield and sugar yield in three sets, was not an important character. Kang *et al.* (1989) also reported the negligible direct effect of fibre content on tons per hectare of cane and sugar. Fibre may be important only from standpoint of milling efficiency and not because of its effect on stalk and sugar yields. High heritability, moderate GCV and genetic advance and negligible direct effects of fibre on stalk and sugar yields suggested that selection for sugarcane clones with optimum fibre content should be relatively easy.

The overall results of correlation and path analysis indicated higher magnitude of contribution of NMS, SSW, stalk length, brix percent, sucrose percent towards stalk and sugar yields. Of these traits, NMS showed the maximum GCV and expected genetic advance, high heritability and direct

effects on stalk and sugar yields. This indicated the importance of NMS as the most reliable selection criterion. However, indirect causal factors, particularly the stalk diameter, have to be taken into consideration while selecting in these early stage interspecific hybrids.

Based on the results, twenty-six clones viz. ISH-001, -002, -009, -023, -028, -031, -041, -043, -068, -112, -131, -137, -153, -165, -186, -246, -354, -360, -362, -370, -375, -385, -391, -409, -427, and ISH-428 which combined most of the traits on par/superior to standards were identified as elite clones. Further, genetic stocks for seven individual traits and red rot resistance were also identified (Table 6). Statistical significance to the general mean and/or standards for respective traits was used as the criterion to isolate these elite donors. Testing for red rot was done against mixture of three major races prevalent in North Western Zone by plug method of inoculation. A total of 27 ISH clones were identified as resistant (R) and moderately resistant (MR) types (Table 6). All these ISH clones are maintained at Sugarcane Breeding Institute, Coimbatore and hence can be utilized in future breeding programmes.

Table 6. Genetic stocks for some important characters

Character	No. of stocks	Name of genetic stocks
Stalk yield	26	ISH-001, -002, -009, -031, -043, -065, -068, -112, -134, -135, -137, -141, -168, -175, -176, -186, -246, -362, -391, -427.
Sugar yield	21	ISH-001, -002, -009, -028, -031, -043, -068, -131, -135, -137, -143, -148, -153, -165, -175, -186, -246, -362, -391, -427.
NMS	21	ISH-134, -135, -137, -141, -142, -143, -145, -146, -147, -148, -149, -150, -155, -168, -175, -176, -225, -274, -280, -290, -385.
St. diameter	35	ISH-002, -006, -022, -023, -028, -029, -031, -036, -038, -044, -052, -054, -056, -058, -068, -103, -109, -112, -113, -114, -118, -139, -156, -157, -161, -165, -178, -246, -1364, -175, -380, -425, -428, -447, -486.
SSW	25	ISH-001, -002, -009, -022, -028, -029, -031, -038, -044, -052, -054, -068, -112, -113, -114, -117, -139, -156, -161, -178, -246, -362, -375, -425, -486.
CCS %	21	ISH-001, -002, -006, -023, -027, -041, -052, -107, -131, -139, -153, -164, -165, -360, -370, -375, -385, -391, -428, -434.
Sucrose %	12	ISH-001, -002, -041, -052, -131, -139, -360, -370, -375, -391, -428, -434.
Red rot	27	ISH-007, -018, -050, -061, -062, -063, -110, -112, -115, -135, -146, -176, -177, -188, -192, -198, -203, -229, -243, -263, -267, -292, -314, -316, -319, -360, -450.

The use of these interspecific hybrid clones would hastens the gains in performance and steps up the variance among progenies, which at present, is diminishing to that of experimental error level in commonly adopted intervarietal crossing programme. The progenies studied subsequently, of these interspecific hybrid clones (F_1) crossed with commercial hybrids were better than the progenies of $F_1 \times$ noble clones (Bakshi Ram and Hemaprabha, 1995). These progenies ($F_1 \times$ commercial hybrids) were not only superior in mean performance for various traits but also resulted in isolation of more number of genotypes significantly outyielding the standards.

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AGRI-DIVERSITY IN NORTH-WESTERN HIMALAYAS

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The North-western (N-W) Himalayas has highly varied agro-ecological conditions and predominantly vegetarian people. The high dependence on plants as food source resulted into the growing consumption of about 180 plant species by the inhabitants. The highly diverse ecology of the N-W Himalayas hosts much varied vegetation. As a consequence, wild relatives of crop plants have also an impressive array of diversity. Among these, the significant species diversity is found for *Allium* (18), *Lactuca* (16), *Taraxacum* (14), *Agropyron* (11), *Vicia* (11), *Solanum* (brinjal) relatives (9), *Chenopodium* (8) and *Lathyrus* (8), besides, wild relatives of species like *Cicer microphyllum* and *Glycine max*.

Key words : North-western Himalaya, agri-diversity, food plants, wild relatives

The North-Western Himalayas include Jammu and Kashmir, Himachal Pradesh and north-western hills of Uttar Pradesh. The people of this zone have been growing and/or collecting large number of plants or plant products from wild habitats for consumption. Consumption of such a large array of plants have been the basis of good stamina and sound health for them since time immemorial. This combined with high agro-ecological diversity has made this region a very rich resources of food plants. The present paper is an attempt to reveal the rich agri-diversity resources of the N-W Himalayas.

Diversity of agro-ecological zones of N-W Himalayas: The region may conveniently be divided into five agro-climatic zones *viz.* (i) plain valleys with warm tropical conditions, (ii) foothills with mild subtropical climate, (iii) mid-hills with cool subtropical conditions, (iv) high hills with temperate climate, and (v) temperate arid zone with dry and sandy soil conditions.

Agri-diversity: The people inhabiting the western Himalayas derive their food from an array of cultivated as well as naturally growing wild plants. The number of plant species grown in the N-W Himalaya may be estimated to be about 10,000 to 12,000. Polunin and Stainton (1985) have also stated that the great variation in climate and habitat is the consequence of enormous variation in the western Himalayan flora even within quite a short distance (20 km). The diversity of human food resources in the western

Himalaya may conveniently be grouped as (a) cultivated food grains, (b) oilseed crops, (c) cultivated and wild vegetables, (d) spices and condiments, wild and cultivated fruits, (f) uncultivated food plants.

(a) **Cultivated food grains:** These constitute the main food items of the populace. They are comprised of large variety of grains such as (i) cereals, (ii) millets, (iii) pulses and (iv) pseudocereals. These are grown mainly in two crop seasons *Kharif* (May-June to Sept.-Oct.) and *Rabi* (Oct.-Nov. to Feb. March or April). The cereals grown are *Triticum aestivum* (wheat), *Hordeum vulgare* L. (barley), *Oryza sativa* L. (rice), *Zea mays* L. (maize). The millets and minor millets include *Eleusine coracana* Goertn. (mandava/mandal), *Setaria italica* Beauv. (kauni/kangani), *Panicum miliaceum* L. (Cheena), *Paspalum scrobiculatum* L. (kodo/kodra), *Echinochloa frumentacea* (mandiva/Jhangara), *Sorghum vulgare* Pers. (Jowar), job's tear (*Coix lachryma-jobi*), *Avena sativa* (Jai).

Pulses or legumes are the major sources of proteins. These are *Cicer arietinum* L. (gram, chana), *Vigna mungo* L. (black gram/mah/urad), *Vigna radiata* (L.) Wilezek. (green gram/moong), *Vigna unguiculata* Walp. (cowpea, lobia, rongi, ruansh), *Phaseolus vulgaris* L. (rajmash, french bean), *Macrotyloma uniflorum* L. (horse gram or kulthi), *Lens culinaris* Medik. (lentil, masur), *Glycine max.* (bhat), *Vigna umbellata* (rice bean), *Vicia faba* L. (bakala), *Pisum sativum* L. (pea/matar), *Vigna aconitifolia* Jacq. (moth/dew gram), *Lathyrus sativus* L. (chikling vetch/khesari dal), *Phaseolus coccineus* Lam. (scarlet bean), *Vigna trilobata* (L.) Verdc. (pillipsera), *Cajanus cajan* Mill. sp. (Red. gram/pigeon pea/arhar), *Phaseolus multiflorus* Willd. (scarlet runner). In the higher elevation of Himalayan mountains, except barley, no other cereals grow and therefore, the staple food constitutes of pseudocereals such as grain amaranth, (*Amaranthus hypochondriacus*, *A. caudatus* Moq., *A. biltum* L., *A. hybridus*), buckwheat (*Fagopyrum esculentum* Moench. 'Ogal' and *F. tataricum* Greuter, 'Phaphra').

(b) **Oilseed crops:** The people of western Himalayas generally rear milch cattle and consume butter and ghee. Besides, vegetable oils are also used in various culinary preparations. These include *Brassica campestris* L. var. toria, var. yellow sarson, var. brown sarson (toria, pili sarson, and kali sarson), *Brassica juncea* H.F.T. (rai), *Linum usitatissimum* L. (alsi or tulsii), *Sesamum indicum* L. (Til tel or Mitha tel), *Perilla frutescens* (Bhanjira), *Ricinus communis* L. (erendi tel), *Prunus armeniaca* L. (zardalu or apricot, or chuli tel), *P. communis* L. (huds or chuli tel), *Aesendra butyracea* Roxb. (chiura), *Bassia latifolia* Roxb., *Eruca sativa* Mill. (taramira).

(c) **Cultivated and wild vegetables:** People in hills grow and even collect naturally growing plants or plant products which are eaten cooked as vegetables. These may be grouped as (i) cultivated vegetables and (ii) uncultivated vegetables. The cultivated vegetable group constitutes *Luffa aegyptiaca* Mill. (ghiya tori, sponge gourd), *Luffa acutangula* Roxb. (kali tori or ridge gourd),

Lagenaria siceraria (lauki, tumra or bottle gourd), *Cucumis sativus* L. (kheera, kakari, or cucumber), *Trichosanthes anguina* L. (snake gourd), *Momordica charantia* L. (karela, bitter gourd), *M. dioica* Roxb. (bhat karela), *Coecirea indica* Naudin (kundru, kundri), *Cucurbita maxima* Duch. (kaddu, kurah), *C. pepo* DC. (chappan kadu). *Brassica rapa* L. (shalgam or turnip), *Raphanus sativus* L. (mooli, radish), *Lycopersicon esculentum* L. (tomato, tamatar), *Daucus carota* L. (carrot, gajar), *Abelmoschus esculentum* L. (bhindi, okra, lady's finger), *Capsicum annuum* L. (Shimla mirch), *Brassica oleracea* var. *capitata* (bandh gobi, cabbage), *B. oleracea* var. *botrytis* (phool gobi, cauli flower), *Solanum tuberosum* L. (alu, potato), *Beta vulgaris* L. (chukander), *B. vulgaris* var. *benghalensis* Roxb. (pahari palang), *Allium cepa* L. (piaj, onion), *A. sativa* (lahsun, garlic), *Lactuca sativa* DC. (salad, lettuce), *Colocasia antiquorum* Schoff. (ghuiya, arbi, kachalu, taro), *C. himalensis* Royle. (gaberi, ghandiali, dahseen), *Amorphophallus campanulatus* Blume, (zamikand, elephant foot yam), *Trigonella foenum graecum* L. (methi).

The uncultivated vegetables are numerous but a few which are consumed as cooked are: *Cucumis trigonus* Roxb. (bislombhai) *Trichosanthes cucumeriuna* L. (jangli chachinda), *Bauhinia variegata* L. (karial, kachnar), *Ficus palmata* Forsk. (daghee, phagre, fig-unripe), *Lepidium sativum* L. (halon, halim, cress), *Salvia plebeia* R. Br., *Dioscorea sagittata* Royle. (tarur, tardi), *Momordica balsamina* (ban kokora), *Euphorbia royleana* Boiss. (chhuhn), *Aloe vera* (ghee kawar, kawar gandal, ghrit kumari), *Nasturtium officinale* R. Br. (chhuchha or water cress), *Boerhaavia diffusa* L. (itsit or utchhata), *Urtica dioica* L. (Bichhu buti), *Malva neglecta* Wall. (Sotsul), *Nelumbo nucifera* Gaertn. (Kamal kakari), *Malva parviflora*, *Phytolacca acinosa*, *Plantago lanceolata*, *Polygonum alpinum*, *Malva verticillata* (Sonchal), *Crambe cordifolia*, *Medicago sativa*, *Limnanthium nymphaeoides*, *Marsilea quadrifolia*, *Medicago sativa*, *Typha angusta*, *Nymphaea alba*, *Coriaria nepalensis*, *Orthosiphon rubicundus*, *Cousinia thomsonii*, *Polygonum bistorta*, *Oxyria digyna* (mountain sorrel), *Agave americana*, *Dioscorea belophylla* Voigt. (dregal), *Diplazium polypodioides* Blume. (lingri, lingru), *Ficus auriculata* Lour. (tiamala, timul), *Cordia dichotoma* Forst. (Lasura), *Selinum wallichianum* DC. (Thoa, celery), *Salvia lanata* Roxb. (Gunni), *Zehneria umbellata* Thw. (gwal kakri), *Amaranthus species* (chauli, Bathu), *Portulaca oleracea* L. (small purslain, Lunak), *Oxalis corniculata* L. (khati, chalmori), *Rumex vesicaria* L. (chuka palang), *Chaerophyllum villosum* Wall. (wild carrot), *Berginia ciliata* (Haw) Sternb. (pahand, patharchatta).

(d) **Spices and the condiments:** A large number of plants or plant products are used as spices and condiments in different parts of the country. In north-western Himalayan region of the country, such plants are; *Carum carvi* L. (kala Jira), *Carum roxburghianum* Benth. (ajmud), *Murraya koenigii* Spreng. (Gandhla, Gandhela, Curry patta), *graveolens* Benth. (dill, soya), *Coriandrum sativum* L. (dhania, coriander), *Foeniculum vulgare* Gaertn. (fennel, sonf), *Capsicum frutescence* L. (red pepper, lal mirch), *Cinnamomum tamala* Nees. (tejpatta), *Amomum subulatum* Roxb. (cardamom, bari elachi), *Zingiber officinale* Ross

(Ginger, Adrak, Ada), *Curcuma longa* Roub. (Haldi, Turmeric), *Angelica glauca* Edgew. (Chora), *Perilla frutescens* (banjira), *Ocimum basilicum* L. (Bhabari), *Allium strachii*, *Rheum emodi*.

(e) **Wild and cultivated fruits:** The diverse agro-ecological conditions of the Himalayan valleys, hills and mountains are highly suitable for growing a range of fruit plants. The economy of hill people find vast potential in horticulture. This is also evident from the development of economy of Himachal Pradesh. A single fruit apple is responsible to transform the entire economy of people in H.P., but potential exists for the growing of a large number of fruits. The cultivated fruits constitute an impressive range and include *Prunus armeniaca* L. (apricot, khumani), *Prunus persica* (L.) Baesch Beyter. (peach, aru), *Malus buccata* (crab apple), *Prunus avium* L. (sweet cherry), *P. cerasus* L. (acid cherry), *P. communis* Huds. (alucha, alubukhara), *Fragaria vesca* L. (strawberry), *Cydonia vulgaris* Pers. (beehdana, quince), *Pyrus communis* L. (pear, naspati, nakh), *Juglans regia* L. (walnut akhrot), *Mangifera indica* L. (mango, aam), *Psidium guajava* L. (guava, amrood), *Punica granatum* L. (anar, pomegranate), *Prunus domestica* L. (plum), *Malus pumila* L. Mill. (seb, seu, apple), *Musa sapientum* L. (kela, banana), *Corylus jacquemontii* L. (bhotia badam, kapasi, hazel), *Citrus jambhiri* Lush. (jambhiri), *C. medica* L. (Bigaura, Ghora, Burunj citron), *C. medica forma lemon* (L.) Hoiroe. (lemon, galgal), *C. medica f. aurantifolia* (christen), Horoe (Lime, kagazi nimbu), *C. limetta* (risso) Lush. (sweet lime, mitha, amritphal), *C. aurantium* L. sub. f. *sinenesis* (L.) Hiroe (sangtra, the tight skinned orange), *C. grandis* (L.) Osbeck (pumelo, shaddock, chakotra), *Prunus amygdalus* Baill (badam, almond), *Grewia asiatica* (phalsa).

Besides above, a large number of fruits are collected/harvested from the wild habitats or forests. Some of these, which need mention include *Aegle marmelos* (bel), *Zizyphus jujuba*, *Buchnanania latifolia*, *Spondias pinnata*, *Rubus ellipticus*, *Eugenia operculata*, *Cordia myxa*, *Hippophae rhamnoides*, *Morus indica*, *Ficus glomerata*, *Phyllanthus emblica*, *Ribes grossularia*, *Elaeagnus latifolia*, *Ribes glaciale* Wall. *R. nigrum* (black current), *R. rubrum*, *Pyrus lanata*, *P. vestita*, *Anona squamosa*, *Limonia acidissima*, *Viburnum stellulatum*, *Punica granatum*.

Genetic Erosion: There has been fast depletion of germplasm in many areas especially in areas where traditional crops are being replaced by the other high value ones. The examples are apple, replacing potato, amaranth, chenopod in Kinnaur and in Lahaul hops, potato and peas etc. have replaced buckwheat, barley etc. About 40-45 years back mandua (*Eleusine corocana*) was in cultivation in Bilaspur district which is not grown now. Similarly *Mucuna capitata* (bali) consumed as fresh pod vegetable is extinct now. *Trichosanthes anguina* is rarely seen in cultivation. Among others, a bold rice variety 'Rohru' cultivated among maize fields is no longer found. Grain chenopod is becoming scarce in hills because of the change in food habits of the people and low yield of the crop.

Diversity of wild relatives in N-W Himalayas: The N-W Himalaya is also reputed to contain some very important genetic resources of wild relatives. Considerable diversity of wild relatives occur for *Allium* sp., *Lactuca* sp., *Chenopodium* sp. and *Trigonella* sp. Besides, other important wild species that occur in N-W Himalayas included *Chaerophyllum villosum* Wall. (wild carrot), *Daucus carota* (a weed of cultivated fields), *Bunium persicum* (Boiss) Fedto, (kalajira, black cumin), *Glycine soja* (bhatta, wild Soybean), *Cicer microphyllum* Benth. (wild gram), *Cichorium intybus* L. (wild chicory), *Avena fatua* L., *A. aspera* Munro var. *roylei* (wild oats), Wild strawberry (*Fragaria indica* Andr., *F. nubicola* Lindl ex Laciata, *F. vesca* L.), wild cucumber (*Cucumis hardwickii*), *C. momordica* Roxb., *C. callosus* (Rohb.) Cogn.), *Vigna capensis* Walp, *Vigna sublobata*, (wild marjoram) *Origanum vulgare* L. (wild thyme) *Thymus serpyllum* L. *Vitis lanata* (Wild grapes), (Wild parval) *Momordica balsamina*, (wild chachinda) *Trichosanthes cucumerica* L.

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SEMIGRAPHICAL METHOD OF ANALYSING GENETIC VARIATION IN MULBERRY (*Morus* spp.)

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Metroglyph and index score analysis was carried out with 22 Indian and 28 exotic genotypes of mulberry maintained in the germplasm collection of Central Sericultural Research and Training Institute, Mysore. The Indian genotypes fall into three morphological complexes which differed among themselves and exotic genotypes fall into two morphological complexes. Maximum exotic genotypes failed to show better phenotypic performance under Indian environment. Maximum frequency of exotic genotypes occurred around an index score ranging from 1 to 6 and Indian genotypes between 7 to 12. On the other hand, most of the indigenous strains fall into low or medium to low category and the exotic genotypes scored high index value for the component traits influencing moisture content of the leaf. Thus greater morphological, physiological and anatomical variability is observed between exotic and indigenous genotypes among the collections under study.

Key words: Mulberry, *Morus* spp., metroglyph analysis.

The base of the mulberry silk industry depends on the mulberry plants which form the only source of food material for rearing silkworm. As the demand for raw silk has increased world over, sericulture is spreading rapidly in both tropical and temperate countries. More than 21 species of mulberry are known to exist in nature, of which majority remain unexplored (Benchamin *et al.*, 1989). Though the total number of mulberry varieties exceed 1000 (Yokoyama, 1959) hardly 10 per cent of them are being cultivated and the popular varieties form just one per cent. In India, about 560 mulberry genotypes were reported and are being maintained at various Indian Institutes. In Central Sericultural Research and Training Institute, Mysore, a total of 400 accessions are maintained, comprising of 117 exotic, 182 indigenous and 101 elite F₁ hybrids. Various parameters for evaluation of mulberry genotypes for growth

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and yield (Dandin and Kumar, 1989), stress resistance (Susheelamma, 1988), disease resistance (Govindaiah *et al.*, 1989) were reported to screen out suitable ones. The success of genetic improvement in any character depends on the nature of variability present in the gene pool for that character. Hence, an insight into the magnitude of variability present in the genepool of crop species is of utmost importance to a plant breeder for starting a judicious plant breeding programme.

The present paper reports the use of metroglyph analysis in analysing morphological variation in a set of 50 introductions of mulberry (*Morus* spp.). In addition to morphological characters, attempts were also made to examine the association between morpho-physiological and anatomical characters influencing water content and retention ability of the leaf in the genotypes. Water content of excised leaves was proposed as index in screening for stress resistance (Dedio, 1975). Of the total weight of leaf, 50-70 per cent is moisture which determines the nutritive quality of the leaves and play an important role in cocoon quality and quantity (Dandin and Kumar, 1989). As the leaves are stored atleast for 8-10 hours, after harvest till last feeding to silkworm in a day, leaves should retain their moisture content to the maximum without drying. Moisture retention capacity of mulberry leaf is also an important consideration and slow drying is one of the main points to be considered for selection (Kasiviswanathan *et al.*, 1973). There is, thus a need for studying the existance of association, if any, between the morpho-physiological and anatomical characters with a view to build up preliminary selection criteria for picking up desirable types.

Metroglyph analysis (Anderson, 1957) is a semigraphic method for studying variability in a large number of germplasm lines taken at a time. This technique was largely adopted for the assessment of variability in Indian vetiver (Ramanujam *et al.*, 1964), maize (Mukherjee *et al.*, 1971), tobacco (Venkatarao, *et al.*, 1973), green gram (Singh and Chaudhary, 1974), triticale (Kamboj and Man, 1983) and cotton (Singh and Nandheswar, 1983).

MATERIALS AND METHODS

The experimental material compared 50 genotypes, of which 22 were indigenous and 28 exotic (Table 1). Since it was not possible to study all the Indian and exotic collection, it was decided to select some promising and popular genotypes among the collection being maintained at Central Sericultural Research and Training Institute, Mysore. All the genotypes have been planted in a single row plot under randomised block design with four replications. In each row, 10 competitive plants were randomly selected and tagged for observation. A large number of metric traits were recorded but metroglyph and index score analysis was carried out with only those characters which

Table 1. List of Indian and exotic mulberry genotypes

Sl. No.	Genotype	Origin	Sl.No.	Genotype	Origin
1.	Assamabola	India	26	English Black	France
2.	Ber - C763	-do-	27	Cattaneo	Italy
3.	Ber- C776	-do-	28	Italian Sarnal	-do-
4.	Ber- S1	-do-	29	Ensatakasuka	Japan
5.	Ber- S799	-do-	30	Gosheo-rami	-do-
6.	Bilidevalaya	-do-	31	Ichihai	-do-
7.	Birds foot	-do-	32	Ichinose	-do-
8.	Botatul	-do-	33	Kairyonezymigaeshi	-do-
9.	Chattatul	-do-	34	Kairyoroso	-do-
10.	Cuckpilla	-do-	35	Katania	-do-
11.	Jatinuni	-do-	36	Kenmochi	-do-
12.	Kaliakutai	-do-	37	Kokuso	-do-
13.	Kanva-2	-do-	38	Kokuso-13	-do-
14.	Local	-do-	39	Kosen	-do-
15.	MR-1	-do-	40	Limnocina	-do-
16.	MR-2	-do-	41	Mizusawa	-do-
17.	OPH-3	-do-	42	Rokokuyoso	-do-
18.	S-30	-do-	43	Roso	-do-
19.	S-36	-do-	44	Senmatso	-do-
20.	S-41	-do-	45	Serpentina	-do-
21.	Sujanpur-1	-do-	46	Shin-Ichinose	-do-
22.	Sujanpur-5	-do-	47	Tsukasaguawa	-do-
23.	Moulai	Burma	48	Fernandodias	Paraguay
24.	China Peking	China	49	Chinar	U.S.S.R
25.	China White	China	50	Sanish-5	-do-

were found significant in the analysis of variance. Metroglyph and index score analysis was largely according to the methods suggested by Anderson (1957). The class intervals of the various morphological physiological and anatomical traits are presented in Table 2 and 3. The range in each character has been represented by the different positions of the rays on the glyph. The index scores have been obtained by allotting numerical values to three grades of expression recognised in respect of each character and summing up the scores received by each genotype for all the characters. The analysis was carried out

under two conditions, *viz.*, on the morphological traits influencing leaf yield and on morpho-physiological and anatomical characters influencing leaf weight and moisture content of the leaf.

RESULTS AND DISCUSSION

The result of the metroglyph analysis on morphological variation are presented in Fig. 1, where each variety is represented by small circles, the X-coordinate of each circle being number of primary branches per genotype and Y-coordinate, leaf yield per plant (Kg) of each genotype. Six other characters have been represented by rays at different positions on the glyphs.

Table 2. Class intervals and index value for eight morphological traits

Characters	Index Value		
	0	1	2
Leaf yield/plant	< 2.23	2.24-4.0	> 4.1
No. of primary branches	17.2	17.3-30.6	30.7
Length of primary branches	136.1	136.2-214.7	214.8
No. of leaves/m length	21.0	0 22.0-28.0	29.0
Root length	26.0	0 27.0-47.0	48.0
Root to shoot ratio by length	0.9	0 0.91-1.79	1.8
Sprouting %	34.3	0 34.4-66.7	66.8
Rooting %	33.12	0 33.13-64.25	64.26

An examination of the Fig. 1 reveals that nine groups could be recognised. The first group includes 12 varieties, of which 10 are exotic and 2 are indigenous which form low yield with minimum number of primary branches. The second and third group had one exotic variety each, which fall under the category of low leaf yield with medium to more number of primary branches. Medium leaf yield with less number of primary branches form the fourth group which had 3 indigenous and 6 exotic varieties. The fifth group consist of 6 genotypes, of which 3 are indigenous and 3 are exotic which form medium leaf yield with medium number of primary branches. Group six comprises 4 genotypes, of which 3 are indigenous and 1 exotic. Group seven includes 7 genotypes, of which 1 indigenous and 1 exotic. Group seven includes 7 genotypes, of which 1 indigenous and 6 exotic came under the category of high leaf yield with less number primary branches. Group eight and nine comprised 7 and 3 genotypes, but all are indigenous which have high leaf yield with medium to more number of primary branches.

It could be seen with regard to leaf yield per genotype and number of primary branches, within groups variation was not much.

Among the exotic varieties, the ray pattern in group I, II and III was more or less similar and the index score ranges from 1 to 6. The ray pattern is also similar between group IV and VII and the index score ranges between

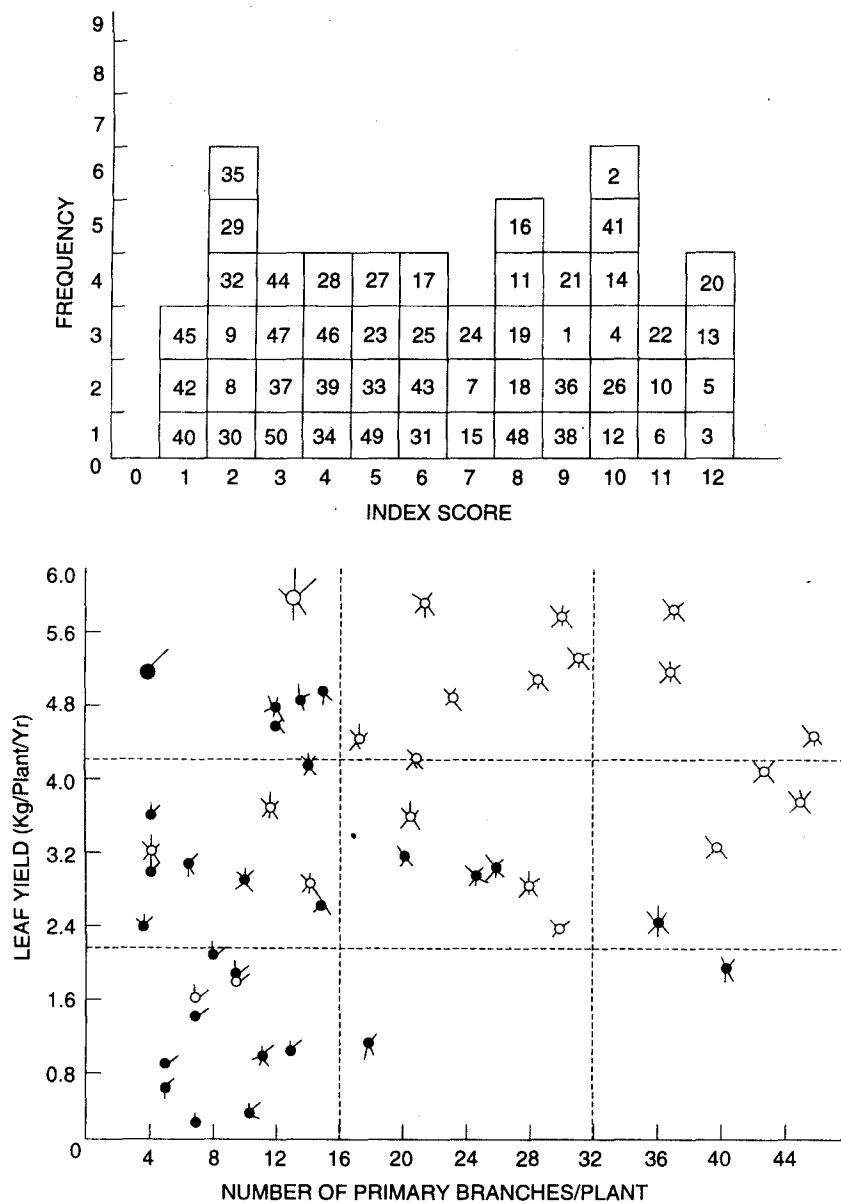


Fig. 1. Scatter diagram of metroglyphs representing morphological characters of 22 Indian (open glyphs) and 28 Exotic (Solid glyphs) mulberry genotypes. Inset (top left) Frequency histogram of index scores obtained by the 50 genotypes.

3 to 10. Thus considerable phenotypic variability exist in exotic genotypes between these two morphologically distinct complexes.

No marked differences observed in the ray pattern between group V and VI which comprised 5 exotic and 5 indigenous and the index score ranges between 5 to 11. This indicated that the exotic and indigenous genotypes in group V and VI possess similar morphological variation. The index score ranges between 9 to 12 in group VIII and IX which comprised 10 genotypes and all are indigenous.

It is apparent from the scatter diagram (Fig. 1), that most of the exotic strains fall into low or medium to low yielding groups. Most of them have poor sprouting and rooting. Two primitive genotypes in group 1 appear to be quite different from all the indigenous collection under study. This indicates that these two genotypes fall in the low range for most of the characters. We can tentatively recognize the indigenous genotypes into three complexes on the basis of morphological traits. The group 1 contains two primitive genotypes fall into low yielding one. Group 4, 5, 6 and 7 formed second complex which included 9 genotypes and all came under medium yield. The third complex include group 8 and 9 comprised only indigenous and are high yielding ones.

The result of the metroglyph analysis on character association for increasing moisture content of the leaf are presented in Fig. 2, where each variety is represented by small circle, the X-coordinate of each circle being moisture percentage of the leaf per genotype and Y-coordinate, weight of 100 leaves of each genotype.

Character association analysis revealed that the strains tend to separate out into seven groups (Fig. 2). Most of the indigenous strains fell into low or medium to low weight of 100 leaves as against their moisture content. Maximum frequency of genotypes found around an index score ranging from 5 to 8 (Fig. 1). The variation was not much within and between groups II, III and IV. Maximum number of genotypes found in group V and the index score ranges from 5 to 12 and the variability within the group found strikingly different. Group VI and VII included 15 genotypes, of which, 9 are exotic and 5 are indigenous and the score ranged between 7 to 13. Comparatively the exotic genotypes showed their superiority over indigenous. The exotic genotypes *viz.*, Shin-Ichinose, Kosen, Ichinose, Kokuso, Goshoe-rami and English Black and one indigenous namely Cuckpilla revealed their superiority over others as they scored high index value from 10 to 13.

The problem at hand resolves itself into one of determining whether there exist any morphological complexes among indigenous genotypes and also their relationship with the exotic germplasm currently being maintained in germplasm collection of Central Sericultural Research and Training Institute, Mysore.

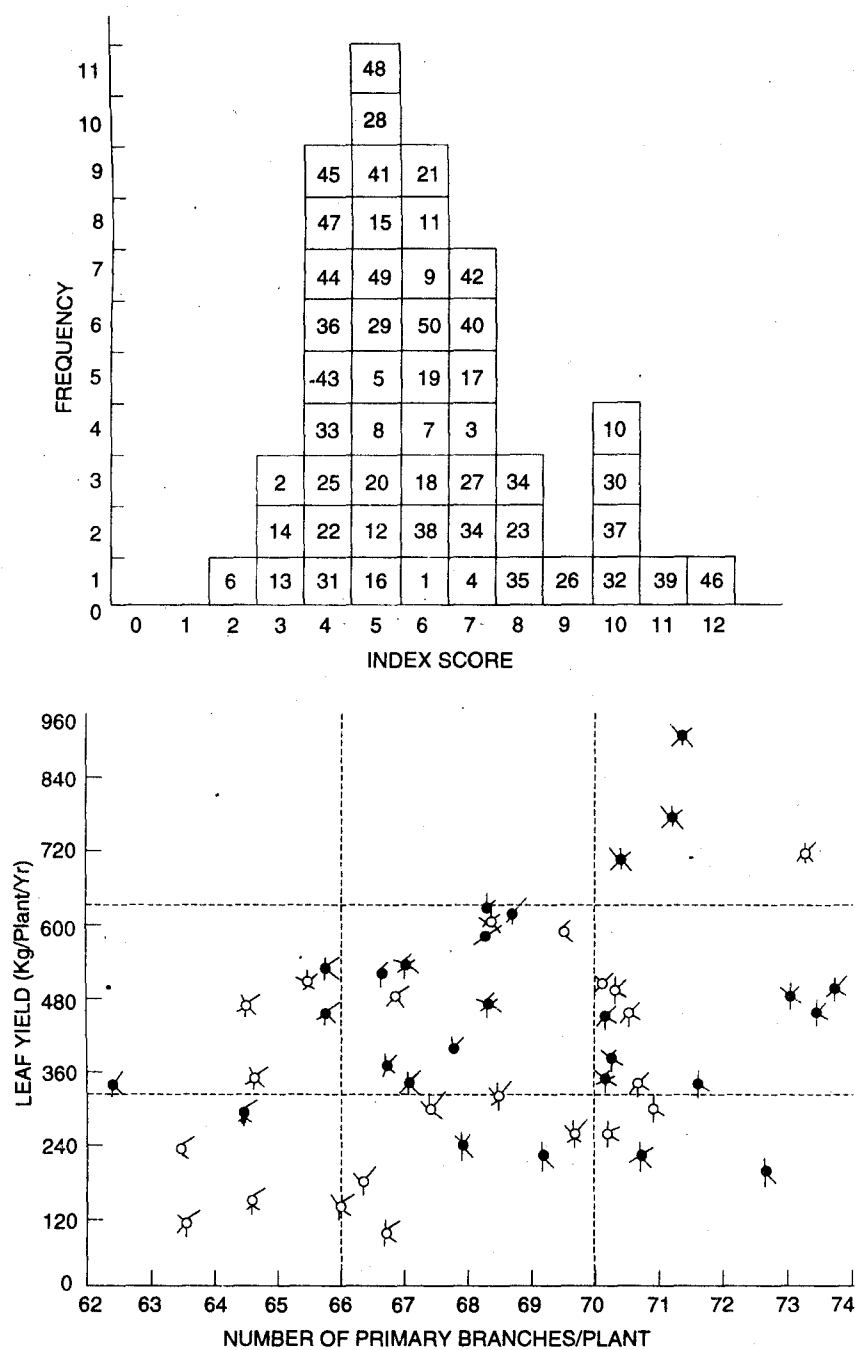


Fig. 2. Scatter diagram of metroglyphs representing morpho-physiological and anatomical characters of leaf of 22 Indian (open glyphs) and 28 Exotic (solid glyphs) mulberry genotypes. Inset (top left) Frequency histogram of index scores obtained by the 50 genotypes.

Table 3. Class intervals and index values for eight morpho-physiological and anatomical traits

Sl. No.	Characters	Index Value		
		0	1	2
1.	Wt. of 100 leaves	394 or below	395-651	652 or above
2.	Moisture %	66.04 or below	66.05-69.81	69.82 or above
3.	Leaf area (cm)	138.07 or below	138.08-179.15	179.16 or above
4.	Stomatal frequency/sq.mm	925.27 or above	660-55-925.26	660.54 or below
5.	Ratio of palisade parenchyma to spongy parenchyma	1.18 or below	1.19-1.84	1.85 or above
6.	Moisture retaining capacity (%)	57.74 or below	57.75-63.01	63.02 or above
7.	Cuticle thickness	3.40 or below	3.41-5.32	5.33 or above
8.	Total chlorophyll content (mg/g)	2.282 or below	2.263-3.033	3.034 or above

From the study of metroglyph analysis, the effect of environment on the phenotypic expression of mulberry genotypes could be well conceived. As was pointed out by Anderson (1957), index score indicates the worth of an individual. In the present set of conditions, strains were distributed normally with respect to index score. Maximum frequency of exotic genotypes occurred around 1 to 6 and indigenous between 7 to 12. Thus greater phenotypic variability observed between exotic and indigenous genotypes among the collections. Genotypes *viz.*, Kanva-2, Ber-S 799, Ber-C 776 and S 41 had greater variability and revealed their superiority over others as they scored the maximum value.

Many exotic varieties failed to show better phenotypic performance under Indian environment. Exotic varieties introduced from temperate countries and the direct introduction of such genotypes was not successful due to non-adaptability and different environmental conditions (Tazima, 1985). The temperate varieties have a different life cycle pattern, poor rooting, slow and delayed sprouting of buds which render them unsuitable for tropical conditions. However, some of the genotypes *viz.*, Kosen and Goshoe-rami proved successful in Kashmir region owing to the climate parallel with the native countries (Bongale, 1989).

On the other hand, maximum exotic genotypes scored high index value for the component traits influencing moisture content and retention ability of the leaf to increase its feeding value to silkworm. Though the characters are highly influenced by various agronomical practices like spacing, irrigation, soil fertility etc., all the strains have shown their own genetic potential under similar set of conditions. Genotypes possess more leaf area combined with less number of stomata, high ratio of palisade parenchyma to spongy parenchyma, more thickness of cuticle increase moisture percentage and moisture retention capacity of the leaf. This is in confirmation with the earlier findings made by Susheelamma *et al.*, (1989) in mulberry and by Hurd (1968) in wheat cultivars.

Crosses among divergent parents are likely to yield desirable combinations. Therefore, a crossing program should be initiated between the genotypes belonging to different groups. The important points to be considered are (i) choice of the particular group from which genotypes are to be selected as parents and (ii) selection of a particular genotype from the selected group. The present study is a preliminary one and can be further improved by taking more Indian and exotic genotypes and by using sophisticated biometrical techniques of multivariate analysis.

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VARIABILITY IN FRUIT CHARACTERS OF MANGO (*MANGIFERA INDICA*) CLONES IN ANDAMANS

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Thirty-six clones of mango (*Mangifera indica*) were studied for two seasons by surveying South, North and Middle Andaman during flowering and fruiting periods. The genetic and phenotypic coefficient of variance, heritability, genetic advance, coefficient of correlation were estimated for weight of fruit, length and breadth of fruit, total soluble solids, acidity, stone weight and pulp weight. Remarkable variability was observed among clones for the characters studied. All these characters exhibited higher estimates of broad sense heritability and that of low to moderate for genetic advance, length, breadth, weight of fruit and weight of pulp had high estimate of broad sense heritability as well as high expected genetic advance. Fruit weight, length and breadth are found to be effective selection index.

Key words: Coefficient of variance, heritability, genetic advance, quality character.

India holds rich genetic diversity in both cultivated and wild relatives of several horticultural crops including mango. In Andamans, mango, the important tropical and sub-tropical fruit crop, were brought from most mango growing areas of India and is distributed unsystematically to most of the Islands and hence, no standard variety has been reported in these Islands suitable for early monsoons. Nevertheless, these genetic resources could be utilized for further upgrading and improvement. Due to unsystematic introduction and indiscriminate multiplication from all types of introduced base material in mango, a lot of variation resulted in the existing population or in clones of the crop. Earlier Santos DEL Rosa *et al.*, (1989), Uthaiyah *et al.* (1990) and Gupta *et al.* (1993) have made similar studies on mango. It is therefore imperative to study the extent of variability in the base population. Most of the plant characters of economic importance are quantitatively inherited and are highly influenced by environmental conditions. It is difficult to adjudge whether observed variability is heritable or due to environment alone. Clonal variation is available in mango growth along the stretches of islands and from island to island in respect of size, shape, fruiting time, weight of fruit and yield in different regions of islands, where these clones are not only in sizable plantations but large variability also exists. Keeping these points in view the

present study was undertaken to study the variability in different population of mango in the Andamans.

MATERIALS AND METHODS

Variability/diversity in mango was explored during 1991-92 and 1992-93 by surveying South, North and Middle Andaman during November to February when flowering and fruiting takes place in most cultivars and again during April to July when fruits were physiologically mature. Observations were recorded for flowering and fruiting behaviour, physico-chemical traits of fruits in 36 accessions of mango in three replicates. For physico-chemical analysis of fruits, five samples in each accession were randomly selected for weight of fruit (g), breadth and length of fruit (cm), total soluble solids (T.S.S.; % Brix), acidity (%), stone weight (g) and weight of pulp (g) in all the 36 accessions/clones. To find out the variability CV - coefficient of variation (Burton, 1952); H - broad sense heritability (Burton and De Vane, 1953), G.A. - expected genetic advance (Allard, 1960) and r - correlation coefficient (Aljibouri *et al.*, 1958) were estimated.

RESULTS AND DISCUSSIONS

Interclonal variation was evident by significant difference among the clones and further a wide range of variability was found in different plant characters studied (Table 1). Highest range of variation was exhibited by

Table 1. Phenotypic variability for different characters in 36 clones of mango

Character	Mean $\pm$ SE	Range	C.D. at 5%
Average weight of fruit (g)	296.50 $\pm$ 1.9	24.70 -896.67	32.00
Average length of fruit (cm)	10.90 $\pm$ 0.3	6.70 - 17.40	0.60
Average breadth of fruit (cm)	8.20 $\pm$ 0.2	4.70-17.40	0.40
T.S.S. (% Brix)	11.52 $\pm$ 0.2	8.20-16.13	0.54
Acidity (%)	0.40 $\pm$ 0.007	0.27 - 0.46	0.02
Stone weight (g)	30.70 $\pm$ 1.0	21.00-47.0	2.50
Pulp weight (g)	271.40 $\pm$ 18.0	53.00-659.00	36.10

weight and pulp of fruit and lowest by acidity of fruit. The phenotypic component of variance in general was higher than genotypic component (Table 2) and the extent of latter component also showed that they are mostly hereditary in nature which is again evident by higher estimates (above 90% of broad sense heritability. All characters under study exhibited higher estimates of broad sense heritability which ranges from 90% (weight of pulp) to 99.5%

Table 2. Variance components, genetic and phenotypic coefficient of variance, heritability (H%) and mean expected genetic advance (GA%)

Character	Variance components		Coefficient of variance		Heritability (H%)	Genetic advance (GA%)
	Phenotypic	Genotypic	Genetic	Phenotypic		
Weight of fruit (g)	793.350	787.850	9.46	9.50	99.4	57.600
Length of fruit (cm)	2.906	2.892	15.54	15.58	98.4	3.528
Breadth of fruit (cm)	9.980	9.920	38.50	38.62	99.5	6.420
T.S.S. (% Brix)	2.248	2.175	0.128	0.130	96.1	2.986
Stone weight (g)	48.143	46.573	0.220	0.225	97.2	13.978
Acidity (%)	0.00184	0.00173	0.1191	0.1192	98.0	0.088
Weight of pulp (g)	2918.14	2429.45	0.181	0.199	90.0	10.117

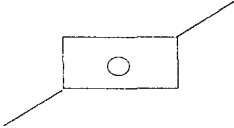
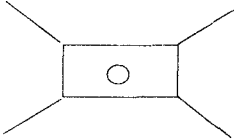
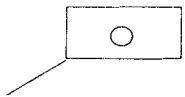
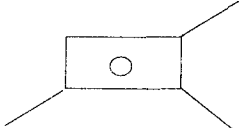
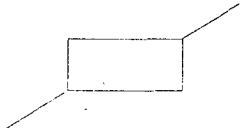
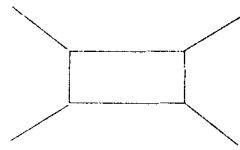
(breadth and weight of fruit). While calculating the coefficient of variation it was found that a few characters had ample scope for bringing about improvement. In case of any selection made thereupon and extent of improvement could be made as 57.6%, 10.1 and 2.99 for fruit weight, pulp weight and TSS, respectively with the 5% selection intensity. Thus, higher magnitude of genetic variability, genetic coefficient, heritability and expected genetic advance, revealed the possibility of profitable selection. Predominant genetic variance also showed that fluctuation due to environmental effect is undoubtedly tolerable. This revealed the predominant effect of additive component of gene action which can be fixed through selection. It has been pointed out that heritability estimates coupled with genetic advance may precisely reflect the progress that will result from selection of best individuals (Jhonson *et al.* 1955). Correlation coefficients estimated in all possible ways among the different pairs of characters are presented in Table 3. Significant correlations of fruit

Table 3. Matrix of simple correlation coefficients

Character	Breadth of fruit	Length of fruit	T.S.S.	Acidity	Stone weight	Weight of pulp
Weight of fruit	0.699	0.843**	0.379	-0.294	0.672**	0.983**
Breadth of fruit		0.650**	0.068	-0.151	0.358	0.729**
Length of fruit			0.119	-0.274	0.640*	0.834**
T.S.S.				-0.013	0.197	0.310
Acidity					-0.175	-0.289
Stone weight						0.623

**Significant at $P < 0.01$ *Significant at $P > 0.05$

Table 4. Meterograph analysis of 36 clones of mango in Andamans

Group	Varieties/clones		Characteristics	
	Acc 1		Weight of fruit	Moderate
			Length of fruit	Moderate
			Breadth of fruit	Moderate
			T.S.S.	Moderate
			Weight of pulp	Moderate
	Acc 2	Acc 12	Weight of fruit	Moderate
	5	14	Length of fruit	More
	6	14	Breadth of fruit	More
		18	T.S.S.	More
	10	19	Weight of pump	Moderate
	11	20		
	Acc 3		Weight of fruit	Moderate
	4		Length fo fruit	Moderate
	8		Breadth of fruit	More
	23		T.S.S.	More
			Weight of pulp	Moderate
	Acc 7		Weight of fruit	Moderate
	21		Length of fruit	Moderate
	33		Breadth of fruit	Moderate
			T.S.S.	More
			Weight of pulp	More
	Acc 15		Weight of fruit	Moderate
	17		Length of fruit	More
			Breadth of fruit	More
			T.S.S.	More
			Weight of pulp	More
	Acc 25		Weight of fruit	Moderate
			Length of fruit	More
			Breadth of fruit	More
			T.S.S.	More
			Weight of pulp	Moderate
	Acc 29		Weight of fruit	More
			Length of fruit	More
			Breadth of fruit	More
			T.S.S.	Moderate
			Weight of pulp	More
	Acc 9	28	Weight of fruit	More
	13	31	Length of fruit	More
	22	32	Breadth of fruit	More
	24	34	T.S.S.	More
	26	35	Weight of pulp	More
	27	36		

weight *versus* fruit length and breadth, stone weight, pulp weight; pulp weight *versus* length and breadth of fruit suggest the scope of direct and indirect effective selection for further improvement. Similar results have been reported by Santos DEL Rosa *et al.*, (1989), Uthaiiah *et al.*, (1990) and Chadha *et al.*, (1993). Hence fruit weight as direct and fruit length and breadth as indirect traits would be better selection index. With the help of metrographic analysis (Table 4), 36 clones (obtained) are divided into eight major groups, characterized by these traits and majority of better clones have higher magnitudes of weight, length and breadth of fruit, total soluble solids and weight of pulp. This is again in agreement with the above mentioned selection index. In addition to these traits regular bearing habit, taste and flavour of fruit would be important characters for clones in Andaman, six promising ones have been selected and multiplied on locally available root stock for further study and improvement (Table 5).

Table 5. Morpho-chemical status of some selected clones

Clone No.	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	T.S.S. (% Brix)	Acidity (%)	Stone weight (g)	Pulp weight (g)	Remarks
6-1-7	246	9.4	7.8	12.4	0.40	31	217	Regular, sweet with red ting, fruit ripens before monsoon, thin skin.
6-1-8	896	17.4	11.3	10.9	0.35	45	848	Regular, ripens in early May.
6-3-1-II	235	11.1	7.1	12.1	0.38	31	204	Regular, tastes excellent, ripens in May.
6-4-6a	311	13.0	7.8	12.2	0.41	32	257	Regular, heavy bearing, fruiting throughout year.
9-1-3a	540	10.2	10.8	16.1	0.31	32	507	Regular, heavy bearing, ripens early May.
6-1-3a	616	15.3	10.6	10.6	0.41	44	509	Regular, tasty, good keeping quality, ripens middle of April.

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PERFORMANCE OF ALMOND GERMPLASM UNDER HIGH HILL TEMPERATE WET ZONE OF HIMACHAL PRADESH

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Almond cultivation in high hill temperate wet zone of Himachal Pradesh is attributed mainly to green almond marketing. Sixteen almond cultivars which were introduced at Temperate Horticultural Research Station, Kotkhai (National Hortorium) from 1961 to 1968 were evaluated for their growth, flowering, yield and resistance to insect, pest and diseases. Cultivars namely Dhebar, Kashmir Seedling, I. X. L. and Drake were recorded as vigorous. About 25 per cent twigs of all the trees showed gummosis, however gum exudation on fruit was very less in Kashmir Seedling (3.0 per cent). All thin shelled cultivars were highly infested with gummosis on fruit and nut and kernel rotting was also more prevalent. No particular relationship exists in bacterial leaf spot and extent of gummosis. Stem gummosis was more associated with attack of flat headed peach tree borer and its attack was more serious in varieties introduced from Kinnaur district. Kashmir Seedling, I.X.L., Drake, Afghanistan Seedling were comparatively less affected.

Key words: Almond germplasm, evaluation, gummosis, leaf spotting, flat headed borer

Almond is an important nut fruit crop which occupy pride place among the temperate fruit plants. It has so far been grown mostly as seedling plantations in the hilly areas of Jammu and Kashmir and Himachal Pradesh. The commercial cultivation of this nut could not be spread in these areas on account of intrinsic problems like damage by rains, wind, frost and hails during the blossoming time and lack of any standard cultivar. There exist vast potential for extending almond cultivation from subtropical to dry temperate areas of Himachal Pradesh, and other states. In high hill temperate wet zone of Himachal Pradesh, sizeable crop is grown for green almond market.

Though large number of germplasm collections are available at various centres but their systematic information on growth and productivity is quite scanty. Keeping this in view, germplasm collection of almond varieties available

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at Temperate Horticultural Research Station, Kotkhai were studied in detail and results are presented in this text.

MATERIALS AND METHODS

Sixteen almond varieties were introduced at Temperate Horticultural Research Station, Kotkhai (National Hortorium) during 1961 to 1968. These varieties are existing in satisfactory condition of growth. The station is located in temperate wet zone of the state which is moderately suited for green almond production. Each variety comprising four trees is planted at 1800 m elevation at a south-western aspect of the station. These trees were trained to modified central leader system and cultural as well as manurial schedules were standard as per recommendation.

Data on growth, flowering and yield were recorded as per standard practices. Cumulative yield record of green almonds were made for 15 years (1981-1995). Varieties were also studied for the incidence of flat headed peach tree borer (*Sphenoptera lafertei* Thompson) which is a serious pest of stone fruits and mainly responsible for gummosis in these fruit plants. Oozing of gum from the main trunk and limbs with elliptical adult emergence holes (old attacks) were also considered. The attack was arbitrarily graded into five categories on the basis of gum oozing and adult emergence holes as healthy (0), low (1 to 10), moderate (11-12), heavy (21-30) and very heavy (31-50).

The data on fruit gummosis were recorded on 100 randomly selected green almonds, at harvest. Stem gummosis, leaf spotting and shot hole were recorded on visual key and depending upon the incidence and intensity were categorised as light, medium, heavy and very heavy incidence.

RESULTS AND DISCUSSION

The data on tree growth and yield parameters are given in Table 1.

Trunk girth and tree height: Maximum growth in terms of trunk girth (50 cm) was recorded in Dhebar followed by Kashmir Seedling (46.0 cm). Merced was least in growth (13.0 cm). Tree height was maximum (5.85 m) in Kashmir Seedling, followed by I.X.L. and Drake. Spillo and Sadwant Raj were least in height.

Yield: Drake recorded maximum cumulative yield (196 kg) as well as average yield per tree (13.06) and yield efficiency (0.146). I.X.L. and Non Pareil ranked second in this aspect and can be categorized as medium producer. Various selections from Kinnaur district namely *Spillo*, *Ribba* etc. showed very poor performance in this region. Although Non Pareil, I.X.L. Merced have been recommended for cultivation in the zone (Anon. 1994), but performance of Merced is not satisfactory.

Table 1. Growth and yield of almond germplasm (under Kotkhai conditions)

Sr. No.	Cultivar	Tree girth (cm)	Tree height (m)	Cumulative yield of green almond (kgs) (1981-1995)	Av. yield (kg) (per year/ tree)	Yield efficiency (kg/cm ²)
<i>Planted on 1961</i>						
1.	Non Pareil	31.0	4.70	125.50	8.38	0.109
2.	Drake	33.0	5.21	196.00	13.06	0.156
3.	I.X.L.	39.3	5.62	135.00	9.00	0.077
4.	Dhebar	55.3	5.00	16.93	1.21	0.005
5.	Thinshelled	18.0	3.50	51.37	3.67	0.142
6.	Tree No. 37	26.0	3.50	42.00	3.00	0.056
7.	Afghanistan Seedling	39.0	4.95	12.80	0.91	0.008
8.	Kashmir Seedling	46.0	5.85	57.60	4.11	0.024
9.	Spillo No. 16	31.0	3.40	2.50	0.18	0.002
10.	Spillo No. 18	25.0	2.00	4.50	0.32	0.006
11.	Riba Selection	34.0	3.20	2.00	0.14	0.002
12.	Sadwant Raj	25.0	2.10	2.02	0.14	0.002
13.	Brigg's Hardshell	33.0	3.00	1.35	0.09	0.001
14.	<i>Amygdalus communis</i>	23.0	2.50	2.92	0.21	0.005
15.	Merced	13.0	2.15	4.10	0.29	0.022
16.	E.C.24199	29.0	3.50	15.03	1.07	0.016

Flowering: Data on flowering parameters are given in Table 2. Kashmir Seedling was the earliest to flower followed by Afghanistan Seedling. According to bloom period, the varieties can also be classified (Table 3).

Early flowering varieties had more flower duration than late ones. Since the region cold winters persist with late spring frosts and snow, hence most of these early flowering varieties failed to crop in most of the years and were considered unfit for this zone in particular.

Disease reaction: Incidence of stem gummosis was rated light to medium in all cultivars except, *Merced* and *Spillo* No. 18 which were almost completely free from the disease. Two to three gumming lesion were present in 25 per cent limbs of susceptible cultivars.

Table 2. Flowering period of almond germplasm (under Kotkhai conditions)

Cultivar		First Flower			Full bloom date			Flowering period			(Duration) (Mean)
		1991	1992	1993	1991	1992	1993	1991	1992	1993	
Planted in 1961											
1.	Non Pareil	3/2	2/15	2/23	3/10	2/26	3/8	16	22	25	21.0
2.	Drake	2/24	2/18	2/15	3/4	2/25	3/3	17	13	33	21.0
3.	I.X.L.	3/1	2/15	2/21	3/9	2/26	3/9	16	16	30	20.6
4.	Dhebar	2/26	2/19	2/6	3/10	3/24	3/15	15	21	26	21.3
5.	Thinshelled	3/2	3/18	2/15	3/12	2/25	3/1	22	33	36	24.0
6.	Tree No.31	3/1	2/13	2/1	-	-	2/10	-	-	-	-
7.	Afghanistan seedling	1/15	1/2	3/1	2/10	2/15	3/10	35	32	18	28.3
8.	Kashmir seedling	1/13	2/12	1/25	1/30	1/20	2/5	36	24	35	31.7
9.	Spillo No.16	1/30	2/28	2/27	2/16	2/26	3/9	18	19	24	20.3
10.	Spillo No.18	2/28	3/1	2/28	3/6	3/9	3/8	30	18	22	20.0
11.	Riba selection	3/8	2/20	2/10	2/26	2/24	2/23	16	13	32	20.3
12.	Sadwant Raj	3/1	2/29	2/26	3/8	3/10	3/10	17	19	24	20.3
13.	Brigg's Hardshell	2/18	2/20	3/2	2/26	3/2	3/12	20	22	19	20.3
14.	<i>Amygdalus communis</i>	2/26	2/25	3/1	3/8	3/1	3/10	24	19	24	22.3
15.	Merced	2/20	2/24	2/22	3/1	3/6	3/3	20	18	31	23.7
16.	E.C. 24199	2/22	2/25	1/18	3/2	3/6	2/25	19	18	34	23.7

Table 3. Classification of almond germplasm according to bloom period (in Kotkhai conditions)

Early flowering (In Jan.)	Mid season flowering (Start flowering in mid to end Feb.)	Late flowering (Flowering in March)
Kashmir seedling	Ribba Selection	Drake, Thinshelled, Non Pareil, I.X.L.
Afghanistan Seedling	Spillo No. 16	
Tree No.31.	E.C. 24199	Merced, Briggs Hardshell, <i>Amygdalus communis</i> , Spillo No.18, Sadwant Raj, Dhebar

Table 4. Insect, pest and disease incidence in almond germplasm (under Kotkhai conditions)

Name of cultivar	Gummosis			Bacterial leaf spotting	Stagmina blight	Incidence of flat headed borer
	Tree	Fruit (%)	Kernel (%)			
Non Pareil	L	80	10	L	M	
Drake	L	90	Nil	L	L	0
I.X.L.	L	70	20	Nil	H	+
Dhebar	M	25	Nil	L	H	+
Thinshelled	L	100	60	NH	Nil	+++
Tree No. 31	L	25	Nil	H	M	0
Afghanistan seedling	L	100	60	L	M	0
Kashmir seedling	L	3	Nil	Nil	L	0
Spillo No.16	M	65	Nil	L	M	+
Spillo No.18	Nil	10	Nil	L	L	+
Riba Selection	L	30	Nil	Nil	Nil	+++
Sadwant Raj	L	25	Nil	H	L	+
Brigg's Hardshell	L	80	80	L	L	+++
<i>Amygdalus communis</i>	L	75	Nil	Nil	Nil	+++
Merced	Nil	45	Nil	Nil	L	++++
E.C.42199	L	-	-	-	-	+++

Keys :-a) Disease incidences

L - Low

M - moderate

H - Heavy

VH - Very heavy/severe

b) Insect attack

0 - Free from insect attack

+ - Low

++ - Moderate

+++ - Heavy

++++ - Very heavy/dying trees

Hard shelled **Kashmir Seedling** showed very little fruit gummosis (3%), Dhebar, Tree No. 31 and Spillo No. 18 were next group of cultivars showing 10-25 per cent fruit gummosis. *Thin Shelled* and *Afghanistan Seedling* were highly susceptible. Kernel gummosis was also present in these cultivars.

Incidence of leaf spotting ranged from light to very high except I.X.L., **Merced**, *Amygdalus communis*, **Briggs Hard Shell**, E.C. 24199, **Ribba Selection** and **Kashmir Seedling** which were free from the disease. Apparently there was no evidence of any clearcut relation between leaf spotting and fruit

gummosis in the field. Jindal and Sharma (1988) have also reported earlier that thin shelled cultivars were more susceptible to gummosis than those having thick shell. Hard shell were reported comparatively resistant to bacterial gummosis (Sharma, 1988).

Incidence of flat headed borer: Four cultivars namely **Drake, Tree No. 31, Afghanistan Seedling** and **Kashmir Seedling** were observed free from the attack of flat headed peach tree borer. **Non Pareil, I.X.L., Dhebur** and **Sadwant Rai** had low incidence of the insect. *Merced* was most badly affected followed by **Briggs Hardshell, Amygdalus communis, E.C. 24199** and **Ribba Selection**. Gumming tendency in stone fruits was mainly associated with insect damage and trees planted in north eastern aspect were least affected. Trees of **Drake, Tree No. 31** and **Kashmir Seedling** had more spread with sufficient foliage which has reduced the attack of the insect at this site. Sharma *et al.* (1990) reported that tree of stone fruits with less spread are more susceptible to damage.

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GENETIC DIVERGENCE IN PARWAL (*TRICHOSANTHES DIOICA* ROXB.)

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The genetic divergence in 23 genotypes of parwal has been assessed utilizing generalised distance and canonical analysis. The 23 genotypes fell into six clusters. Two canonical vectors needed to be considered to account for about 82% of variation. Geographical isolation has not contributed to the genetic divergence. The observed genetic divergence therefore seems to be possibly due to phenotypic differences in genotypes background. The inter-cluster divergence was maximum in cluster III, where as inter-cluster distance was maximum between cluster I and II. Fruit volume followed by pulp weight and seed weight appeared to contribute maximum to genetic divergence. Genetic drift and selection in different environments seem to cause greater genetic diversity rather than genetic isolation.

Key words : Parwal (Pointed Gourd), genetic, divergence, multi-variate analysis, geographical isolation, genetic drift, pivotal condensation

Parwal (pointed gourd) is an important vegetable crop grown in Bihar, Uttar Pradesh, Orissa, Gujarat, Madhya Pradesh and parts of Andhra Pradesh. It is delicious and nutritious vegetable with good medicinal properties. Recently, it has been reported that the property of lowering blood sugar (Chandrasekha *et al*, 1988), total cholesterol and serum triglycerides and increase the level of phospholipids and HDL-cholesterol (Sharma and Pant, 1988) and anti-ulcer effects (Takano *et al.*, 1990) in *Trichosanthes* fruits.

A meaningful classification of germplasm that enables to distinguish genetically close and divergent types, is a pre-requisite for any plant breeding programme. Anticipating potential danger associated with the use of narrow base in a dynamic breeding programme, research efforts are underway in Central Horticultural Experiment Station to develop parwal hybrids with sustainable yield. With the development of advanced biometric techniques such as multivariate analysis based on Mahalanobis D^2 statistic (1936), quantification of the degree of divergence among biological populations and assessing the relative contribution of different components to the total divergence at inter and intra cluster levels have now become possible.

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MATERIALS AND METHODS

Twenty-three widely grown genotypes of parwal (long, small, round and oval fruited) from **diara** lands of Bihar and Uttar Pradesh were grown in a randomized block design with three replications at Plandu farm of Central Horticultural Experiment Station, Ranchi. Each entry had one row of five metre length, spacing between rows and within the rows being 1m and 45 cm, respectively. Experiment was repeated for a period of three years. Observations were recorded on five randomly selected plant per replication for each entry on vine length, node number, fruit weight, fruit length, fruit breadth, fruit volume, pulp weight, seed weight and number of seeds per fruit. The fruit yield and number of fruits were recorded on plot basis.

Cannonical analysis and Mahalanobis generalised distance (1936) were used for assessing the genetic divergence between the population. All possible D^2 values among 23 parwal genotypes were computed utilizing the varietal means and variances in respect of 11 characters. The co-variances between character pairs were also computed (Rao, 1952). For generalised distance, un-correlated linear functions of the original values were obtained by transforming the original correlated unstandardized character means by the method of pivotal condensation (Rao, 1952). For determining group constellations, a relatively simple criterion suggested by Tocher (Rao, 1952) was adopted.

RESULTS AND DISCUSSIONS

Highly significant variation was found among the 23 parwal genotypes in all the characters except node number and fruit weight (Table 1). The D^2 values (253) obtained between 23 parwal genotypes showed considerable range (1.29 to 59.85). This wide range suggests the existence of appreciable genetic divergence in the genotypes tested. The 23 populations could be grouped into 6 clusters and composition of different clusters are presented in Table 2. Among these, cluster III consists of 9 genotypes followed by cluster II (5) and cluster I (5), where as, cluster IV, V and VI with one genotype each. The material under study included collections from **diara** lands of Uttar Pradesh and Bihar with distinct phenotypic fruit characters. Clustering pattern of parwal genotypes indicates that geographical isolation has not contributed much to the genetic divergence. The observed genetic divergence, therefore, seems to be possibly due to differences in genotypes background. While, Krishna Prasad *et al* (1993) reported that geographical isolation is no way related to the genetic divergence in the landraces of slicing cucumber. In such situation where the role of geographic isolation is negligible, genetic drift and selection in different environments could lead to greater diversity.

Table 1. Analysis of variance for RBD for 11 characters studied in 23 genotypes of Parwal

Characters	@ Replications (8)	Treatments (22)	Error (1.76)	SEM ($\pm$)	CV (%)	CD (1t 5%)	DD (at 1%)
Yield/plot	0.72	5.05**	1.51	0.41	58.21	1.13	1.49
No. of fruits/plot	918.42	5221.03**	2393.73	16.30	69.46	45.07	59.23
No. of seeds/fruit	16.72	27.78**	14.73	1.27	21.88	3.53	4.64
Seed weight	24.86	87.38**	20.66	1.51	22.72	4.18	5.50
Pulp weight	24.86	87.38**	20.66	1.51	22.72	4.18	5.50
Fruit volume	84.98	233.46**	84.92	3.07	23.17	8.48	11.15
Fruit length	1.04	5.54**	1.19	0.56	16.94	1.00	1.32
Fruit weight	154.06	74.73	88.50	3.13	33.37	-	-
Node number	4350.30	1609.00	1581.43	13.25	63.85	-	-
Vine length	1389.89	4010.13**	992.55	10.50	316.66	29.02	38.14

@Degrees of freedom in parenthesis

**Significant at 1%

Table 2. Composition of different clusters

Cluster number	No. of genotypes in cluster	Name of the genotypes
I	5	CHES-2, CHES-21, CHES-22, CHES-26, and CHES-34
II	6	CHES-5, CHES-8, CHES-11, CHES-19, CHES-21, CHES-28
III	9	CHES-4, CHES-6, CHES-7, CHES-12, CHES-14, CHES-17, CHES-18, CHES-19, and CHES-29
IV	1	CHES-20
V	1	CHES-14
VI	1	CHES-1

The intra and inter cluster distance of six clusters was presented in Table 3. Three clusters namely, cluster IV, V and VI had only one genotype each. Of the remaining three, intra cluster divergence was maximum in cluster III ($D = 2.78$) and the minimum for cluster I ($D = 1.66$). The divergence between cluster II and IV was the least, the "D" value being 1.10. Cluster I was highly divergent from cluster VI followed in order by cluster II and III. The maximum inter cluster distance was reported between cluster I and VI (7.69) followed by cluster II and VI (7.29).

Table 3. Intra and inter cluster D² values values in parval

Cluster	I	II	III	IV	V	VI
I	2.76 (1.66)	5.05 (2.24)	8.75 (2.95)	12.10 (3.47)	21.71 (4.65)	59.24 (7.69)
II		5.21 (2.28)	5.05 (2.24)	1.22 (1.10)	17.94 (4.23)	53.15 (7.29)
III			7.73 (2.78)	6.80 (2.60)	14.00 (3.75)	48.96 (6.99)
IV				0	6.77 (2.60)	38.55 (6.20)
V					0	37.92 (6.15)
VI						0

Based on 11 characters, canonical analysis confirmed the clustering pattern obtained by D² statistic. Total contribution of all vectors is 129.58 and per cent contribution of first and second vector was 42.19 and 39.84, respectively. The contribution of each character towards divergence is presented in Table 4. The character fruit volume (22.13%) contributed maximum towards genetic divergence followed by pulp weight (18.58%) and seed weight (14.23%). However, the least contribution was made by vine length (1.19%) followed by fruit length (2.37%). The potent variables like fruit volume, pulp weight and seed weight can be used as parameters in selecting genetically diverse parents for hybridization.

Table 4. Percent contribution of each character towards genetic divergence

Character	Frequency of appearing 1st rank	% contribution towards genetic divergence
1. Yield/plot	15	5.93
2. No. of fruits/plot	11	4.35
3. No. of seeds/fruit	27	10.67
4. Seed weight	36	14.23
5. Pulp weight	47	18.58
6. Fruit volume	56	23.13
7. Fruit breadth	12	4.74
8. Fruit length	6	2.37
9. Fruit weight	22	8.70
10. Node number	18	7.11
11. Vine length	3	1.19

The character means over clusters (Table 5) showed wide range in their values clusterwise. The genotypes of cluster I showed maximum pulp weight and fruit volume; whereas the genotype CHES-14 present in cluster V showed maximum for number of fruits, no. of seeds per fruit, seed weight and fruit breadth. The only genotype i.e. CHES-1 present in cluster VI showed maximum mean values for the characters yield per plot, fruit length, fruit breadth, node number and vine length. The superiority showed by these two genotypes *viz.*, CHES-1 and CHES-14 for majority of the attributes can be successfully be exploited in the future breeding programme.

Table 5. Cluster means for eleven characters in Parwal

	Characters	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Total Mean
1.	Yield/plot (kg)	1.93	2.15	2.02	2.01	1.84	3.82	2.29
2.	No. of fruits/plot	63.10	72.50	71.45	63.11	87.77	75.30	72.20
3.	No. of seeds/fruit	18.70	17.50	17.12	15.22	19.27	15.80	17.86
4.	Seed weight (g)	5.43	5.10	5.70	6.54	7.19	56.69	5.94
5.	Pulp weight (g)	22.25	20.00	20.62	14.64	11.51	16.89	17.65
6.	Fruit volume (cc)	45.63	38.02	38.42	31.15	39.80	41.22	39.04
7.	Fruit breadth (cm)	2.89	2.88	3.12	3.17	3.22	2.97	3.04
8.	Fruit length (cm)	6.08	5.99	6.56	6.12	7.26	9.44	6.90
9.	Fruit weight (g)	28.37	27.97	28.31	25.01	26.18	32.33	28.02
10.	Node number	74.30	68.04	47.87	61.20	46.00	73.82	61.86
11.	Vine length (m)	6.30	5.90	5.08	5.74	3.72	6.59	5.55

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FORAGE DESMODIUMS : ECOLOGY AND POTENTIALS

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The *Desmodiums* belong to a large genus *Desmodium* comprising 450 species, distributed all over the world. In India, 49 species are reported from tropical, subtropical and temperate regions. Almost all the species are important pasture legumes and being palatable and nutritious are considered as alfalfa of the tropics. Research attention on the forage value of desmodiums is rather low in comparison to other pasture legumes. In this paper, the ecology and potentials of *Desmodium* of forage value are highlighted.

Key words: Forage Desmodiums, grazing preference, legume persistence, stress tolerance, environmental adaptations

INTRODUCTION

The Desmodiums are highly palatable and nutritious and are considered as alfalfa of the tropics (Allen and Allen, 1981). Almost all the species are important pasture legumes having diploid chromosome number $2n = 22$. Most of the species are in wild state and await discovery. Due to biotic interferences, many species are on the verge of extinction. Several species such as *D. heterocarpon*, *D. triflorum*, *D. gangeticum*, *D. tortuosum*, *D. diffusum*, *D. heterophyllum* are extensively used as fodder and pasture crop in India. This paper presents the state of research information particularly on the ecology and potentials of Desmodiums and highlights the prominent species and future research areas.

Taxonomy

Most Desmodiums are perennial herbs and shrubs but rarely trees and are distinguished by jointed, usually indehiscent pods. The approaches to taxonomic classification of the genus *Desmodium* vary and so also the estimates of the number of species. Most likely, there are 450 species distributed all over the world. The Asiatic species of *Desmodium* (Ohashi, 1973) defy division into smaller ones due to continuity of the main character. Schubert (1963), who has published widely on the taxonomy of American and African species of *Desmodium*, has recognized three subgenera in the Mexican *Desmodium* and is of the view that inflorescence and loment characters serve the strong basis for classifying Desmodiums.

Ohashi (1973) placed *Desmodium* in the tribe Caronilleae, subtribe Desmodiinae together with 24 other genera including the closely related *Codariocalyx*, *Dicerma*, *Dendrolobium*, *Hegnera*, *Phyllodium* and *Tadehagi*. Huthinson (1964) elevated the subtribe to the range of tribe viz., Desmodieae.

Origin and Distribution

South-east Asia (India, Thailand, Malaysia and China) is considered as the primary centre of diversity in *Desmodium*. The second major centre of diversity is Mexico, the Mexican species being distinct from Asian counterparts. According to Index Kewensis about 160-180 species of *Desmodium* are reported from equatorial region (0-10°Lat), 180 species from tropical and subtropical regions (10-250° Lat) and 110 species from the temperate regions (above 250°Lat) (Jackson, 1895). Most of the *Desmodium* species are distributed within the altitude range of 1500-2200 m above m.s.l. (Singh *et al.* 1988).

D. uncinatum and its two cultivars viz. *D. uncinatum* cv. green leaf and cv. silver leaf are native to South and Central America and are distributed in humid and subhumid tracts (Bogdam, 1977). *D. canum*, a woody trailing perennial is widespread in the wet tropics, common in Fiji, Hawaii, North and Central America (Bermudez *et al.* 1968). *D. scorpiurus* is distributed in tropics but has originated in America, whereas *D. discolor* is widespread in subtropics of Brazil, Argentina and Paraguay (Boelcke, 1964). *D. intortum*, a trailing perennial is native to Panama and Columbia and is widespread in South America specially eastern slopes of the Andes and Brazil (Whiteman, 1968). *D. tortuosum*, a perennial herb is native to West Indies and is spread over Florida, Central and South America and tropical Africa (Bogdam, 1977), whereas *D. barbatum* is widely distributed in Florida, USA, Argentina and tropical Africa (Burkart, 1952).

D. heterocarpon and *D. heterocarpon* var. *heterocarpon* are native to South-east Asia, Sri Lanka and India (Bermudez *et al.* 1968). *D. gyroides*, a fodder in India is indigenous to South East Asia (Bryan, 1966). *D. heterophyllum*, a perennial prostrate creeper is native to and distributed in Eastern Hemisphere, Mauritius, South-east Asia and Malaysia, whereas *D. biarticulatum*, an erect herbaceous annual is a very good fodder in coastal ecosystem and *D. capitatum* is a browse species. Both of these species are distributed in India, Sri Lanka and Malaysia (Farinas, 1965).

Recent survey of *Desmodium* lists 33 species and 14 sub-species from India (Hussain and Kapoor, 1990). Most of the species occur in humid regions of Assam, West Bengal mountains and Eastern Himalayas. The species occurring in Assam regions are *D. griffithianum*, *D. khasianum*, *D. econum* and *D. racemosum*. The species viz. *D. oxyphyllum*, *D. podocarpum*, *D. laburnifolium* and *D. floribundum* are mostly confined to the Western Himalaya (Table 1).

Table 1. Habitat and distribution of forage Desmodiums

Species	Habit	Distribution
<i>Desmodium adscendens</i> (SW) DC.	Er, H, P	Eastern Himalaya, Sikkim
<i>Desmodium bakeri</i> Balakr.	Tr, H, A	Plains of Mysore, Western Ghat
<i>Desmodium barbatum</i> (L.) Benth. Subsp. <i>saulierei</i> (Sch.) Ohashi	Er, H, P, E	N.E. Himalayas, Sikkim
<i>Desmodium benthami</i> Balakr.	Tr, H	Nilgiri, Western Ghats
<i>Desmodium biarticulatum</i> (L.) Muell	Tr, S	Coastal saline soil A.P. Tamil Nadu, Orissa, India,
<i>Desmodium caudatum</i> (Thumb.) DC.	Er, H/S, P	Bengal,
<i>Desmodium concinnum</i> DC. var. <i>concinnum</i>	Er, H/S, P	Khasi hills, Eastern Himalaya
<i>Desmodium concinnum</i> DC. var. <i>retusum</i> (D.Don) Ohashi	Er, S	Upper Punjab, Simla, Khasi hills
<i>Desmodium dichotomum</i> (Klein ex Willd.) DC.	St, H, P	Bundelkhand, Bengal Plains, Western peninsula
<i>Desmodium dolabriforme</i> Benth.	Er, H/S, P.E	Western peninsula
<i>Desmodium elegans</i> DC.	Er, S	Punjab, Western Himalayas
<i>Desmodium ferruginum</i> Wall. ex Thw Subsp. <i>wynaadense</i> (Bedd. ex Gamble) Ohashi	Er, S	Tamil Nadu, Nilgiri
<i>Desmodium ferruginum</i> Wall ex Thw. Subsp. <i>ferruginum</i>	Er, S.	--
<i>Desmodium gangeticum</i> (L.) DC.	Er/Pr, H/S, P	Orissa, A.P., M.P., Bengal
<i>Desmodium griffithianum</i> Benth.	Tr, H	Upper gangetic plains
<i>Desmodium gyroides</i> (Link) DC.	Er, S	Central and Eastern Himalaya, Khasi hills, Upper Bengal
<i>Desmodium heterocarpon</i> (L.) DC. var. <i>heterocarpon</i>	Er/De, H/S, P	Throughout Eastern tropics Tamil Nadu, A.P. Orissa
<i>Desmodium heterocarpon</i> (L.) DC. var. <i>strigosum</i> Van Meeuwon	Er, S	M.P., West Bengal N.E. India
<i>Desmodium heterophyllum</i>	Tr, H, P	Throughout India, Malaysia, China, Philippines
<i>Desmodium khasianum</i> Prain	Er, S	Khasi hills, Assam, Eastern Himalaya
<i>Desmodium kulhaitense</i> Clarke ex Prain	Er, S	Sikkim, Khasi hills, Bengal
<i>Desmodium laxiflorum</i> DC.	Er, S	Assam, Garhwal, Kumaon hills
<i>Desmodium laxum</i> DC.	Er, S	Western Peninsula, Sri Lanka
<i>Desmodium likabalicum</i> Bennet and Chandra	Er, S	Nilgiri, South India

(Contd. to next page)

<i>Desmodium microphyllum</i> (Thunb.) DC.	Pr, H, P	Eastern Himalayas Ceylon
<i>Desmodium motorium</i> (Houtt.) Merrill	Er, H/S, P	Himalaya, Assam, Ceylon, Tamilnadu, Orissa, A.P.
<i>Desmodium multiflorum</i> DC.	Er, S	Khasi hills, Eastern Himalayas
<i>Desmodium neomexicanum</i> A. Gray	St, H, P	Eastern Himalayas, Sikkim, Khasi hills
<i>Desmodium oblongum</i> Wall. ex Benth.	Er, S	South India, Nilgiri, Tamil Nadu
<i>Desmodium oojeinense</i> (Roxb.) Ohashi	T	West Bengal, Tamil Nadu, A.P., Orissa, M.P.
<i>Desmodium oxyphyllum</i> DC. Subsp. <i>oxyphyllum</i>	Er, S	Tropical Himalaya, Simla, Garhwal
<i>Desmodium podocarpum</i> DC. subsp. <i>podocarpum</i>	Er, H/S, P.	Khasi hills, Sikkim
<i>Desmodium pryonii</i> DC.	Er, H, P	Western Himalayas, upper Punjab
<i>Desmodium pulchellum</i> (L.) Benth.	Er, S	M.P. West Bengal, Orissa, A.P. and Tamil adu
<i>Desmodium renifolium</i> (L.) Schindl	Tr, H, A	Eastern Himalaya, Western Peninsula
<i>Desmodium repandum</i> (Vahl) DC.	Er H/S, P	Nilgiri, South India, Malaysia
<i>Desmodium sequax</i> Wall.	Er, S	Sikkim, Himalayas, Simla, Kumaon
<i>Desmodium spirale</i> DC.	Er, H, A	Himalaya, Sikkim, Upper Punjab
<i>Desmodium styracifolium</i> (Obeck) Merrill	Er, S	Assam, Eastern Himalaya
<i>Desmodium tortuosum</i> (SW.) DC.	Er, H, A	Eastern Himalaya
<i>Desmodium triangulare</i> (Retz.) Merrill Var. <i>triangulare</i>	Er, S	Tamilnadu, Nilgiri, A.P. Orissa
<i>Desmodium triangulare</i> (Retz.) Merril Var. <i>congestum</i> (Wall. ex wt. & Am.)	Er, S	North Bengal, N.E. India
<i>Desmodium triflorum</i> (L.) DC.	Pr/Tr, H, P	Throughout India
<i>Desmodium velutinum</i> (Willd.) DC. Var. <i>velutinum</i>	Er, H/S, P	Dry regions, West Bengal, Assam, Orissa
<i>Desmodium velutinum</i> (Willd) DC. Var. <i>longibracteatum</i>	Er, H, P	Sikkim, Khasi hills, North-East India
<i>Desmodium velutinum</i> (Willd.) DC. Var. <i>Sikkimense</i> (Sch.) Ohashi	Er, H, P	Sikkim, N.E. India
<i>Desmodium lonatum</i> Mig	Er, S	Hills of South India, Tamil Nadu

Er = Erect

H = Herb

P = Perennial

Tr = Trailing

A = Annual

S = Shrub

E = Endemic

St = Straggling

Pr = Prostrate

De = Decumbent

T = Tree

The western Ghats are rich in species of *Desmodiums*. In the Nilgiris and surrounding areas, *D. gardneri* and *D. rufescens* are present. Species occurring in Eastern and Western Himalayas are *D. laxiflorum*, *D. pulchellum*, *D. cephalotes*, *D. gyrans* and *D. parviflorum*.

• Only a few peninsular species occur in Assam and the Western Himalaya viz. *D. heterophyllum* and *D. inerme*. In addition to these, *D. triflorum* is a very common species all over India. *D. cephalotes*, reported for the first time from India, confined to the hilly tracts of Assam (Datta and Babu, 1968). Beside this, *D. salvifolium*, *D. tortuosum*, *D. neomericanum*, *D. macaraguense*, *D. canum*, *D. rigidum*, *D. perflexum*, *D. distortum*, *D. heterophyllum*, *D. uncinatum* are the introductions (Paroda and Arora, 1986).

Environmental adaptations

Desmodium species grow on a wide range of soils viz. clay loam, light clay, sand, ferruginous acid soils and red basaltic loams, wide range of annual average rainfall from 900-3000 mm and rather low ambient temperature range from 25-30°C (Table 2).

Table 2. Environmental adaptations of forage *Desmodiums*

Species	Soil texture	Soil pH	Rainfall (mm)	Temperature (°C)	Altitude (m)	References
<i>D. uncinatum</i>	Sandy, Clay loam red basaltic loam	5.0	900-3000	25-30	1500-1800	Mears <i>et al</i> 1964
<i>D. intortum</i>	Wide range of soil	5.0	875-3475	25-30	600-2500	Bryan, 1969
<i>D. sandicense</i>	Sandy, clay soil	6.0	750-1075	25-30	-	Andrews and Norris 1961
<i>D. discolor</i>	Acid to sandy loam	6.5	-	-	-	-
<i>D. heterocarpon</i>	Wet, mineral soil	5.0	1250-1500	15-25	-	Kretschmer, 1974
<i>D. heterophyllum</i>	Sandy, clay acid soil	5.0	15-4000	15-25	200-700	Whiteman, 1968
<i>D. gyroides</i>	Acid and alkaline soil	6.0	2000-4000	15-25	1000	Andrews and Norris 1961
<i>D. canum</i>	Wide range of soil sandy, light clay	6.5	1250-1500	25-30	900-1700	Kretschmer, 1974
<i>D. barbatum</i>	fertile acid soil	6.5	1000-2000	25-30	-	Otero, 1952
<i>D. biarticulatum</i>	Saline, sandy soil	5.0	1500-2000	30-40	-	Otero, 1952

Persistence and tolerance

Most of the species of *Desmodium* withstand adverse environmental conditions such as high temperature, drought, flood, shade, overgrazing, burning etc. (Table 3).

Table 3. Stress tolerance of forage *Desmodiums*

Species	Cold	Shade	Flood	Drou- ght	Cutting and overgrazing	Fire	Salinity	Reference
<i>D. uncinatum</i>	M	-	H	H	H	-	-	Wang <i>et al.</i> 1985
<i>D. intortum</i>	M	M	-	L	H	-	L	Rortar, 1970
<i>D. sandwicense</i>	-	-	H	H	M	M	-	Whiteman 1968
<i>D. triflorum</i>	L	M	H	H	M	-	L	Wang <i>et al.</i> 1985
<i>D. heterophyllum</i>	L	M	M	H	H	L	L	Kelly, 1964
<i>D. gyroides</i>	-	-	M	H	H	L	-	Bryan, 1966
<i>D. canum</i>	H	-	-	-	L	L	-	Thro and Shock 1987
<i>D. barbatum</i>	H	-	M	-	M	M		Bermudes <i>et al.</i> 1968
<i>D. biarticulatum</i>	M	H	L	H	H	H	H	Farinas, 1965
<i>D. heterocarpon</i> var <i>heterocarpon</i>	-	M	H	H	-	L	-	Kretschmer <i>et al.</i> 1976
<i>D. discolor</i>	M	-	M	H	-	-	-	Farinas, 1965
H= High			M = Medium			L = Low		

Palatability

Leaves, terminal shoots and stolons of *D. uncinatum* are grazed by cattle. It shows profuse growth during autumn and spring. *D. heterophyllum* is less palatable but resistant to heavy grazing (Huang, 1967). Leaves and shoots of *D. canum* are highly preferred by livestock (Milford, 1967). *D. barbatum* is preferred by cattle and it makes good hay and crop at 20-30 cm height before flowering (Bermudez *et al.* 1968). *D. triflorum* is recommended for poultry, specially for baby chicks (Farinas, 1965). *D. intortum* is an excellent fodder for baby chicks and in deforested highlands, it is used as a hedge plant (Squibb *et al.* 1978). *D. velutinum* is highly palatable with high dry matter and crude proteins (Mzamani and Agishi, 1986). *D. cinereum*, *D. distortum* and *D. discolor* have higher percentage of green leaves during dry season (Labri *et al.* 1993).

D. tortuosum is used as green chop and hay in tropics but it tends to disappear under prolonged grazing stress. *D. ovalifolium* has relatively poor palatability (Brumbu, 1980). *D. distortum* and *D. gyroides* produce massive crop of fodder preferred by cattle. *D. discolor* is highly palatable to livestock and it makes useful supplement in late summer when grasses have turn dry. Its foliage can be grazed or made into an excellent silage or hay.

Forage yield and quality

Forage yield of different species of *Desmodium* varies considerably depending on the soil type and fertility status (Table 4). *D. discolor* produces

Table 4. Forage quality of *Desmodiums*

Species	Crude protein (%)	Crude fibre (%)
<i>Desmodium adscendens</i>	15.3	19.42
<i>D. canum</i>	15.6	-
<i>D. aparines</i>	22.1	-
<i>D. intortum</i>	17.8	31.0
<i>D. sandwicense</i>	11.9	-
<i>D. scorpiuros</i>	15.5	29.3
<i>D. tortuosum</i>	18.6	44.6
<i>D. triflorum</i>	13.6	35.0
<i>D. uncinatum</i>	14.4	42.0
<i>D. varians</i>	12.3	37.9
<i>D. barbatum</i>	15.6	31.1
<i>D. discolor</i>	15.5	-
<i>D. gangeticum</i>	12.95	-
<i>D. cephalotes</i>	30.2	-
<i>D. heterocarpon</i>	32.9	-
<i>D. triquetrum</i>	29.6	-
<i>D. nicaraquense</i>	22.0	-
<i>D. distortum</i>	22.5	-

24-30 t/ha green foliage in Zimbabwe (Whyte *et al.* 1969). *D. canum* yields 5.0-6.5 t DM/ha with crude protein content 15-60% (Whitney, 1970). Forage yield from *D. sandwicense* is very low (3.75 t DM/ha). The Green leaf desmodium is a high yielder giving several cuts but increased cutting frequency reduces the yield. The forage yield of *D. discolor* ranges from 6.3-7.5 t DM/ha. The

yield of pure silver leaf sward is reported as 6.43 t DM/ha (Clatworthy, 1977). After 3 months planting, 2nd harvest yield 2.8 t DM/ha. *D. intortum* produces 19 t/ha of green matter (Benge, 1987). In South Western islands of Japan *D. intortum* and *D. uncinatum* produce 11.41 t DM/ha and 6.38 t DM/ha respectively (Soji *et al.* 1987).

Seed production

Environmental conditions influence seed production in desmodium. Seed yield is 330 kg/ha in *D. uncinatum* and 18-20 kg/ha in *D. barbatum* (milford, 1967). *D. discolor* and *D. intortum* produce 200 kg/ha and 80-100 kg/ha of seeds respectively (Otero, 1952). The recommended seed rate for sowing is 4-8 kg/acre in *D. intortum* and 4-16 kg/acre in *D. uncinatum*. In general, seed rate for desmodiums is 5-8 kg/ha (Kanodia and Patil, 1981). The seed yield is 20-80 kg/ha in *D. canum*. Seed requirement for broadcast is very high (20-40 kg/ha) in *D. intortum* and very low (3-5 kg/ha) in *D. heterocarpon* var. *heterocarpon* (Young *et al.* 1964).

Seed germination

Seed germination of *Desmodiums* varies in different environmental conditions. The seeds of *D. tortuosum* shows 65-86% germination when treated with zinc solution (Paramathama and Surendran, 1990). The germination is 70-97% at 50°C in *D. cephalotes* and *D. gyrans* except *D. pulchellum* which has very poor germination. At 20°C, the germination of *D. cephalotes* and *D. gyrans* gradually decreased and finally ceased altogether and increased salinity from 0.125-0.2 m NaCl increased germination from 37-45% (Datta and Sen, 1987).

Green seeds have better germination percentage than brown seeds irrespective of their method of scarification, when both type of seeds of *D. velutinum* are stored in hot water having 80°C and conc. H_2SO_4 to increase germination. The seeds treated with acid have lower percentage of germination (Akinola and Afolayam, 1961). The seeds of *D. intortum* show 95% germination (Risopoulous, 1966) but the seeds of *D. biarticulatum* are moderately viable (Farinas, 1965).

Propagation methods

Desmodiums spread well by creeping stem which root at the nodes. The segmented pods break up when matured and seeds are scattered. In suitable soil it can spread vigorously.

Economic importance

The species of *Desmodium* are variously used by the local/aboriginal people in their day-to-day life. The details of uses of different species are given in Table 5.

Table 5. Economic and medicinal uses of forage *Desmodiums*

Species	Parts used as fodder	Medicinal	Others
<i>D. latifolium</i>	Stems and leaves	-	Used as broomsticks, fibres for paper making (Jain, 1963)
<i>D. tiliaefolium</i>	-	Roots carminative tonic and used in biliousness complaints (Watt, 1889-96)	Used in paper making
<i>D. cephalotes</i>	Pods are poisonous to cattle (Duthie, 1960)	-	Foliage used as food by Santals
<i>D. triflorum</i>	Foliage used by cattle	The plants are applied in scorpion sting (Singh <i>et al.</i> 1992) wounds & abscesses	Pods are eaten, used as soil stabilizer
<i>D. caudatum</i>	Foliage used by cattle (Duthie, 1960)	-	-
<i>D. diffusum</i>	Foliage used by cattle	Used to relieve cold & cough in children (Bhalla <i>et al.</i> 1992)	-
<i>D. parviflorum</i>	Foliage used by cattle, goat and camel (Duthie, 1960)	The decoction is used to cure cough & cold	Foliage is eaten by Santals
<i>D. microphyllum</i>	Used by cattle	The decoction of the plant is used in urinary trouble due to stone (Sinha, 1987)	-
<i>D. pulchellum</i>	Used by cattle	Root nodules and leaves are used in toothache (Maikhuri & Ramakrishnan 1992)	-
<i>D. triangulare</i>	Used by cattle	The decoction is used in biliousness of cattle (Jain and Tarafdar, 1970)	-
<i>D. gangeticum</i>	-	The seed smoke is used to remove insect from the body of cattle (Kapur <i>et al.</i> 1992) Smoke inhaled in crude hyper acidity (Satpathy and Oanda, 1992). The root decoction is used in fever (Bhalla <i>et al.</i> 1992).	
<i>D. laxiflorum</i>	-	Roots are used in chronic fever (Sinha, 1987)	
<i>D. capitatum</i>	-	Root decoction is given in discharge of blood from urine and it is given in respiratory trouble with <i>Solanum indicum</i> . Leaf with tobacco is applied in ulcers (Sharma and Sharma, 1992).	

Pests and diseases

The species of *Desmodium* are attacked by viral, fungal and bacterial diseases. *D. intortum* is resistant to nematode *Meliodogyne*, whereas *D. uncinatum* is least resistant to it (Kretschmer *et al.* 1980). The nematode *Meliodogyne incognita* and *Meliodogyne arenaria* cause rootknot disease in *D. heterocarpon* var. *heterocarpon*. Little leaf and *Xanthomonas* attacks have been reported in *D. canum* (Kretschmer *et al.* 1980). *D. uncinatum* is highly susceptible to little leaf virus but *D. intortum* is resistant to it (Hutton and Gray, 1967). The pathogen *Colletotrichum capsici* causes severe leafblight in *D. gangeticum* having small brown spot on the leaves initially and later turning chocolate coloured (Bharadwaja and Dwivedi, 1969). Rootknot nematode occur in *D. heterocarpon* var. *florida*. *D. adscendens* and *D. intortum* cv. green leaf are resistant to *Meliodogyne* nematode and no galls are reported in the roots of these species. *D. heterophyllum* is highly susceptible to legume little leaf (Kretschmer, *et al* 1980).

Future research

Forage *Desmodiums* presently under cultivation in India are mostly exotic with a variety of diseases and pest problems. These legumes show high forage as well as seed yields under monocropping on fertile soils. For introduction of legumes in order to improve natural rangelands, there is dearth of *desmodiums* in India. On the contrary, India is a huge repository of naturally growing wild *Desmodiums* ranging from lowherbs, shrubs, to tree forms. The *desmodiums* are concentrated in humid hilly tracts and also fanout to semi-arid tracts. Therefore, in order to identify suitable *Desmodiums* for rangelands in the above areas, exploration and evaluation of *Desmodiums* of all forms should receive high priority. The Indian *Desmodiums* comprising of 49 species can also serve as genetic resources for plant improvement programmes.

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EARLY GROWTH PERFORMANCE OF LATIN AMERICAN *PROSOPIS* SPECIES IN INDIAN ARID TRACT

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Six exotic *Prosopis* species, mainly of Latin American origin (i.e. *P. nigra*, *P. flexuosa*, *P. chilensis*, *P. alba*, *Prosopis* hybrid and *Prosopis* species-peruvian) were studied for their early growth performance. Moreover, these exotics are simultaneously compared with *P. juliflora* for early growth behaviour. *Prosopis* species-peruvian and *P. alba* have shown best over all growth performance. In general, *P. juliflora* could not attain better overall growth than these exotics. The high degree of adaptability and appreciable early growth performance of *Prosopis* species (peruvian) and *P. alba* make them a very suitable candidate for arid zone plantation forestry activities.

Key words : *Prosopis*, exotic, agro-forestry, silvi-pastoral

INTRODUCTION

In the arid part of Indian sub-continent situation of fuel wood availability is highly alarming as the natural forest cover in the region is almost negligible. The tree/shrub species found in this region, are distributed sparsely and are slow growing by nature. Therefore, a massive afforestation programme using fast growing tree species is urgently required in order to bring such lands under good canopy cover. Evaluation of exotic tree species introduced from isoclimatic regions may be helpful in this context. *Prosopis juliflora* introduced in India in 1877 has been proved a suitable tree species for this region due to its very high degree of adaptability (Muthana and Arora 1983), but farmers in the region do not prefer it much due to thorny nature of the species and also due to some other apprehensions associated with this species, as agricultural crops are adversely affected by the establishment of this species. Besides *P. juliflora*, there are more than 40 species of genus *Prosopis* but till date not much work could be initiated on these species. Present paper summarizes the relative growth performance of six exotic *Prosopis* species and naturalised local *P. juliflora* in environmental condition of arid tract.

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MATERIALS AND METHODS

Seeds of six *Prosopis* species of Latin American origin, viz., *P. nigra*, *P. chilensis*, *P. flexuosa*, *P. alba*, *Prosopis* hybrid and *Prosopis* species (peruvian) procured from Texas, USA and were evaluated for their early growth behaviour at Central Arid Zone Research Institute, Jodhpur, India. The growth performance of these exotics were compared with local *Prosopis juliflora*. Seeds of all the species were first sown in nursery in polythene tubes containing uniform rooting medium comprising of FYM, soil and sand mixed in 1:1:2 ratio. In March 1991 and after five months (in the month of July), seedlings were outplanted on the field. Planting was done at the spacing of 2.5 m × 4.0m in randomised block design with four replications. Plants were watered fortnightly in summer and once in a month during winter @ 15 litres/plant only in first year of planting. Two hoeing in each year were carried out to control the weeds. Data were recorded on survival, plant height, collar diameter and crown diameter by standard silvical procedures, and analysed using Duncan's multiple range test (DMRT) as given in Gomez and Gomez (1983).

RESULTS AND DISCUSSION

Survival percentage of all the species (Table 1), showed that after 3-years maximum survival was in *P. nigra* followed by *P. chilensis*.

Table 1. Survival percentage of different species

Species	1-year	2-year	3-year
<i>P. nigra</i>	90.37	90.25	90.25
<i>Prosopis</i> hybrid	85.78	79.22	79.22
<i>P. flexuosa</i>	74.29	66.41	66.41
<i>P. alba</i>	83.34	80.48	80.48
<i>P. chilensis</i>	83.64	81.41	81.41
<i>Prosopis</i> species - peruvian	76.47	68.94	68.94
<i>P. juliflora</i>	85.00	70.00	70.00

and *P. alba* and minimum was recorded in *P. flexuosa*. Means of plant height and collar diameter recorded during three consecutive years (at yearly interval in the end of each growing season) and that of crown diameter at the end of third year only, of all the species are given in Table 2. In first recording (i.e. after first growing season), *Prosopis* species (peruvian) attained maximum average plant height which remained stable in next two successive years (i.e., after second and third recording, respectively). However, in last recording (i.e., after third year of growth) no statistical differences were found among *Prosopis* species (Peruvian), *P. alba*, *P. chilensis* and *Prosopis* hybrid. In first recording

(i.e., after first year growth), the performance of *P. juliflora* was poorest in respect of plant height but in successive recordings it improved a lot. In last recording it also found a place in the category of *P. alba*, *P. chilensis*, *P. flexuosa* and *Prosopis* hybrid.

Table 2. Means of plant height of seven *Prosopis* species over three years

Species	Plant height (cm)			Collar diameter (cm)			Crown diameter (cm)
	1991	1992	1993	1991	1992	1993	1993
<i>P. nigra</i>	43.75d	78.25d	134.25c	0.59d	1.16d	1.79c	273.75ab
<i>Prosopis</i> hybrid	50.50bcd	92.75bc	185.25ab	0.80b	1.47c	2.40b	282.50ab
<i>P. flexuosa</i>	58.50b	101.25b	171.75b	0.69c	1.29d	2.27bc	261.25b
<i>P. alba</i>	49.00cd	89.75c	188.00ab	0.93a	1.81b	3.39a	321.751b
<i>P. chilensis</i>	53.00bc	100.00bc	183.00ab	0.92a	1.79b	2.84 ab	292.75ab
<i>Prosopis</i> species-Peruvian	89.25a	160.00a	212.25a	0.88a	2.16a	3.10a	328.00a
<i>P. juliflora</i>	39.50a	89.75a	166.60b	0.40e	1.28d	2.83ab	284.25ab

Note: Means having a common letter within a column are not significantly different at $p < 0.05$.

Collar diameter in first recording was found to be maximum for *P. alba* followed by *P. chilensis* and *Prosopis* species- peruvian and minimum was in case of *P. juliflora*. It remained maximum till last recording for *P. alba* (3.39 cm/plant), however, statistically differences were not found significant with *P. chilensis*, *Prosopis* species (peruvian) and *P. juliflora*. Minimum collar diameter was recorded in *P. nigra*.

The crown diameter was found to be maximum in *Prosopis* species-peruvian and minimum in *P. flexuosa*. Mean annual increament in plant height and collar diameter for all the species studied are given in Table 3. The total increment between first and last recording was found to be maximum in *P. alba* for both plant height and collar diameter and minimum was in case of *P. nigra*.

From the data collected and analysed for early growth behaviour of introduced exotic *Prosopis* species, it was discernible that all of them are quite adaptable to environmental conditions of hot Indian arid tract, however, the over all performance of *Prosopis* species (peruvian) was highly appreciable, and closely followed by *P. alba* and *P. chilensis*. As far as relative performance of local *P. juliflora* with these exotic *Prosopis* species is concerned *P. juliflora*, in general, could not attain the over all growth better than the exotics. The

Table 3. Mean annual increment of seven *Prosopis* species over three years for plant height and collar diameter

Species	Plant height (cm)			Collar diameter (cm)		
	1991-92	1992-1993	Total	1991-1992	1992-1993	Total
<i>P. nigra</i>	34.50	56.00	90.50	0.57	0.63	1.20
<i>Prosopis</i> hybrid	42.25	92.00	134.75	0.67	0.93	1.60
<i>P. flexuosa</i>	42.75	70.50	113.25	0.60	0.98	1.58
<i>P. alba</i>	40.75	98.25	139.00	0.88	1.58	2.46
<i>P. chilensis</i>	47.00	83.00	130.00	0.87	1.05	1.92
<i>Prosopis</i> species-Peruvian	70.75	52.25	123.00	1.28	0.94	2.22
<i>P. juliflora</i>	50.25	76.85	127.10	0.88	1.55	2.43

thorny nature of *P. juliflora* is main constraint for non-adoption of this species by rural masses in plantation forestry and agro-forestry programmes. On the other hand, exotic *Prosopis* species (peruvian) and *P. alba* are non-thorny in nature and as such can be successfully introduced in place of *P. juliflora*. Singh and Singh (1993) reported that some of the above discussed exotic *Prosopis* spp. (*viz.*, *P. alba*, *P. pallida* and *P. chilensis*) are very suitable for silvi-pastoral plantations (*Leptochloa* grass as herbaceous component) in salt affected soils.

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ANALYSIS OF GENETIC DIVERGENCE IN SEED STANDS OF *BAUHINIA VARIEGATA* LINN.

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Studies were conducted to assess the magnitude of genetic divergence among 20 seed stands of *Bauhinia variegata* from different agroclimatic zones of Himachal Pradesh, Panjab and Uttar Pradesh at 12 months growth phase. These studies were also carried out to identify promising superior diverse stands for their utilization in future improvement programmes. Genetic divergence assessment by using Mahalanobis D^2 analysis led to grouping into nine clusters. Five seed sources fell in cluster I, one in II, two in III, one in IV, seven in V and one each in cluster VI, VII, VIII and IX. Maximum and minimum distances were observed between clusters VII and VIII and clusters V and VI, respectively.

Key words : *Bauhinia variegata*, genetic divergence, D^2 statistics, cluster analysis.

Bauhinia variegata is a medium sized tree with elongated spreading crown and green foliage. It is characteristic to mixed dry deciduous forests and is useful for its lean winter fodder, fuel, fiber and small timber. The tree parts have diverse medicinal values. The bark is antinflamatory, astringent and used in skin diseases and ulcers. The dried buds are used as remedy for piles and dysentery. Flowers are light antidysenteric and cure diseases of bile, cough and menorrhagia (Kirtikar and Basu, 1933; Chopra *et al.*, 1956; Chuneekar and Pandey, 1969). *Bauchinia variegata* is a unique tree used for agroforestry because of its multiple uses. In northern India it is planted in the agricultural field bunds and in pure culture system. A quantitative estimation of genetic diversity present among different seed stands/sources helps the breeder to attempt a cross between desirable but diverse genotypic stands for generating sufficient genetic diversity for a rapid progress in the improvement programmes. Multivariate analysis has been found to be a potential biometrical tool in quantifying the degree of divergence in the germplasm (Mahalanobis, 1936; Rao, 1952). It has been extensively used as an efficient tool to find out genetic divergence among agricultural Crops (Murthy and Pavte, 1962; Murthy and Arunachalam, 1966). Among tree crops, it has been used by Burley et al

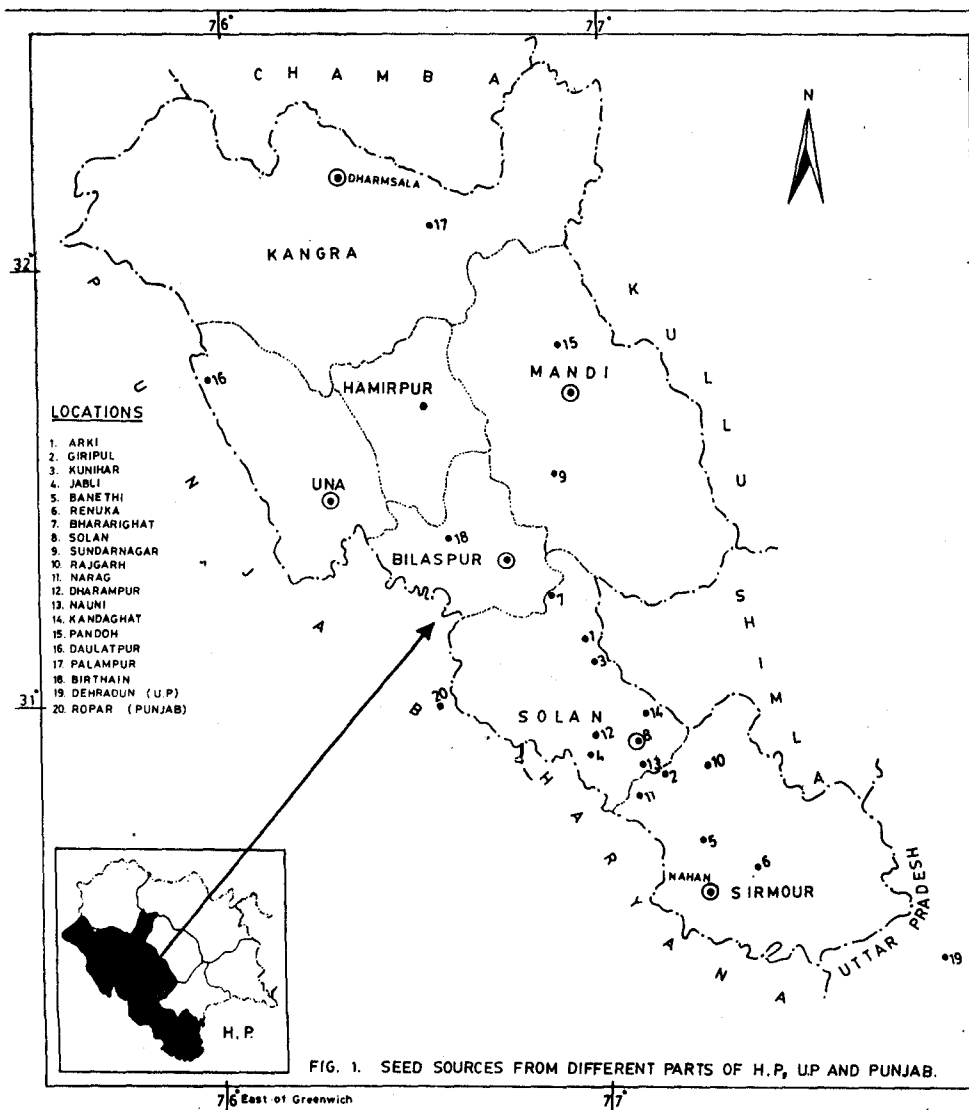


Fig. 1. Seed sources from different parts of H.P., U.P. and Punjab

(1971) in two year old trees of 25 provenances of *Eucalyptus camaldulensis*, Burley and Borrows (1972) in *Pinus kesiya*, Andrew (1973) in 16 provenances of *E. camaldulensis*, Khosla et al (1979) in *Populus ciliata* and Pandey et al (1995) in *Populus deltoidis*. The present studies were under taken, at 12 months growth period, to identify promising seed sources to be utilized in crossing programmes.

MATERIALS AND METHODS

Seeds were collected from twenty seed sources of *Bauhinia variegata* from different agroclimatic zones of HP, Panjab and UP (Fig. 1). The seeds were

Table 1. Mean data for different characters of *Bauhinia variegata* linn

Sr. No.	Seed sources	Height (cm)	Collar dia. (cm)	No. of Leaves	Internodal Length (cm)	No. of Nodes	Leaf area (cm ²)	No. of branches
1	Arki	44.86	7.08	29.00	3.07	14.53	48.15	3.50
2	Giripul	36.46	5.56	15.60	3.27	11.20	33.98	1.77
3	Kunihar	49.20	6.60	25.73	4.09	11.93	52.95	3.53
4	Jabali	52.80	7.38	21.80	3.41	14.40	52.61	2.67
5	Benathi	52.33	6.55	21.06	3.68	14.00	57.18	1.87
6	Renuka	50.96	5.82	17.63	3.62	14.00	55.36	1.50
7	Bararighat	51.16	7.32	25.73	3.32	15.86	56.20	3.50
8	Solan	61.70	7.95	33.70	4.12	14.93	69.78	3.73
9	Sundernagar	42.20	6.38	26.76	3.59	11.66	41.95	2.30
10	Rajgarh	54.06	6.98	23.23	3.43	15.26	59.71	2.57
11	Narag	42.80	6.28	19.36	3.76	11.13	42.81	1.67
12	Dharampur	51.63	7.28	32.76	3.23	16.00	54.91	4.10
13	Nauni	44.50	6.90	17.40	3.20	13.93	39.96	2.00
14	Kandaghat	56.80	7.18	32.76	3.65	15.53	67.01	6.33
15	Pandah	51.61	7.50	30.96	4.26	12.13	57.86	2.33
16	Dharampur	50.06	6.67	27.20	3.56	14.00	56.73	4.10
17	Palampur	59.63	7.76	29.86	4.04	14.80	68.97	3.97
18	Birthian	53.66	7.01	24.56	3.58	14.60	61.25	2.30
19	Dehradun	54.46	7.50	20.63	7.39	14.33	63.76	2.37
20	Ropar	56.36	8.20	22.11	3.63	14.06	55.15	2.03
Mean		50.56	7.03	24.89	3.61	13.91	52.41	2.96
CD (0.05)		3.002	0.662	3.222	0.542	1.742	2.593	0.342

sown in randomized complete block design with three replications. An area of 2 m² per treatment per replication was taken to accommodate 24-25 seedlings at a distance of 25 cm from seedling to seedling and 50 cm from row to row. Ten seedlings other than the border ones were randomly selected in each treatment/stand replication wise and observations on seven different metric traits viz., seedling height, collar diameter, number of leaves, number of branches, internodal length, number of nodes and leaf area were recorded from individual seedlings at 12 months growth period. The data so collected was subjected to multivariate and canonical analysis (Rao, 1952).

RESULTS AND DISCUSSION

The mean data of different characters are given in Table 1. The seed sources showed significant variation for all quantitative characters. The variation ranges were observed for seedling height (36.46-61.70 cm), collar diameter (5.56-8.80 cm), number of leaves (15.60-33.70), number of branches (1.8-4.40), internodal length (3.07-4.26 cm), number of nodes (11.13-16.00) and leaf area (33.98-69.78 cm).

Based on D² value, 20 seed sources were grouped into nine clusters as per the method described by Tocher and reported by Rao (1952). The criterion used for clustering was that any two genotypes/seed sources belonging to the same cluster should, at least on an average, show a smaller D² value than those belonging to different clusters. The clustering pattern of these twenty seed sources is depicted in table 2. Cluster I contained five seed sources,

Table 2. Clustering pattern of 20 genotypes on the basis of genetic divergence in *Bauhinia variegata* Linn.

Clusters	Seed stands
1	1, 3, 7, 4, 12
2	9
3	16, 20
4	13
5	10, 11, 5, 18, 6, 19, 15
6	17
7	2
8	8
9	14

cluster II one, cluster III two, cluster IV one, cluster V seven, cluster VI to IX contained only one seed source each. The intra cluster distances ranged from 0.00 to 92.43 (Table 3) with the maximum value of 92.43 in cluster III followed by 49.59 in cluster V, 32.40 in cluster I and 0.00 in clusters II, IV,

VI, VII, VIII and IX as they possessed only one seed source. The intra cluster distance was less than the corresponding D^2 values indicating more divergence of genotypes between the clusters. Surendran and Chandrasekharan (1988) also reported similar results in 35 half sib progenies of *Eucalyptus tereticornis* Sin.

Table 3. Average intra and inter cluster D^2 values in *Bauhinia variegata*

	1	2	3	4	5	6	7	8	9
1	32.40	64.81	46.25	77.73	65.11	76.14	194.55	187.27	151.18
2		0	121.45	49.76	89.86	234.66	71.13	275.46	66.94
3			92.43	98.98	91.72	91.88	151.65	142.28	145.93
4				0	73.10	213.50	75.36	267.79	359.83
5					49.59	108.17	212.09	126.72	280.04
6						0	435.79	10.51	106.34
7							0	526.80	156.53
8								0	154.50
9									0

The pattern of distribution in these nine clusters showed that there was considerable amount of genetic divergence in these seed sources. Calculation of inter cluster distances revealed the maximum value of 526.80 between cluster VII and VIII, indicating that Giripul and Solan were most divergent seed sources followed by VI and VII cluster i.e. Palampur and Giripul and minimum divergence was available for clusters VI and VIII (Palampur and Solan) indicating their close relationship with each other. The importance of different seedling characters in intercluster divergence was further studied by comparing cluster means for different characters. Significant differences between these two clusters were observed for seedling height, collar diameter, number of leaves, internodal length and leaf area (Table 4). Higher cluster means were

Table 4. Character means for 9 clusters of 20 *Bauhinia* genotypes

Character	I	II	III	IV	V	VI	VII	VIII	IC	VD	% contri
Seedling height	49.93	42.10	50.21	44.50	51.33	59.63	34.46	61.70	56.80	3.002	10.94
Collar diameter	7.13	6.38	7.74	6.90	6.77	7.76	5.56	7.95	7.18	0.662	18.42
No. of leaves	27.00	26.76	24.64	17.40	22.87	29.86	15.60	33.70	32.76	3.222	13.16
No. of branches	3.46	2.30	3.58	2.67	2.63	3.97	3.50	3.73	6.33	0.413	11.62
Internodal length	3.40	3.59	3.65	3.20	3.72	4.04	3.27	4.12	3.65	0.542	11.24
No. of nodes/ seedling	14.54	11.66	14.03	13.90	13.55	14.80	11.20	14.93	15.53	1.742	19.49
Leaf area	52.90	41.95	55.94	29.96	56.20	68.97	33.98	69.78	67.01	2.593	15.11

obtained in cluster IX for number of branches and number of nodes/seedling. The contribution of individual character towards divergence indicated higher magnitude (19.47%) for number of nodes/seedling and collar diameter (18.42%), leaf area (15.11%), number of leaves (13.16%), number of branches (11.62%) and internodal length (11.24%). However, contribution due to seedling height was observed to be much lower (10.94%). Martin *et al* (1981) also examined variation in okra genotypes and distinguished 5 out of 29 characters.

While selecting the seed sources as parents, in addition to genetic divergence, other practical considerations such as disease and insect reaction and quality index should also be taken into account. The estimation of genetic divergence has a wide scope in tree improvement as it helps in identifying the diverse genotypes for a crossing programme. Thus on the basis of present findings it is suggested that crossing between clusters from Solan and Giripul and Palampur and Giripul will result in wide spectrum of variability with transgressive segregates for increased seedling height and collar diameter in the subsequent generations and the selection for these traits will be effective with high heterotic response.

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CHARACTERIZATION AND UTILIZATION OF INDIAN JATROPHAS

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Several species of the genus *Jatropha* found in India were collected and evaluated. Apart from their use as ornamental and energy crops, the genus *Jatropha* represents a potentially valuable source of germplasm for castor breeding as they possess very rare and beneficial characteristics, such as drought resistance, photoperiod insensitivity, resistance to wilt and tolerance to lepidopteran insect pests besides, desirable oil quality. Tissue culture protocols developed for *Jatropha* offer scope not only for widening the genetic base of castor through somatic hybridization and genetic transformation but also in the improvement of *Jatropha per se* by both conventional and *in vitro* techniques as the available variability in the latter is quite narrow.

key words : *Jatropha* sp., characterization, utilization, interspecific hybridization, tissue culture

The genus *Jatropha* (family Euphorbiaceae) is morphologically diverse encompassing more than 200 species which are distributed chiefly in the seasonally dry tropical regions of America, Africa and India. Dehgan and Webster (1979) recognized two subgenera (*Jatropha*, *Curcas*), ten sections and ten subsections. About nine species have been recorded in India which mostly belong to the Subg. *Jatropha* except *J. curcas* which belongs to the subg. *Curcas*. Several species are cultivated for their ornamental or curious leaves and flowers, while few are grown for their economic uses (Anonymous 1959). *Jatrophas* are rich sources of hydrocarbons (27.0 to 48.5% seed oil content) and in the recent past the species *J. curcas* has evoked much interest all over the world as potential petrocrop besides being a drought tolerant perennial (Takeda, 1982; Martin and Mayeux, 1985). Certain members of the genus *Jatropha* have closer morphological resemblances with castor (*Ricinus communis* L.), besides possessing resistance to insect pests, diseases and livestock which led to the speculation of exploiting *Jatropha* in the genetic upgradation of castor belonging to a monotypic genus (Sathaiah and Reddy, 1985; Reddy *et al.*, 1987). However, systematic studies on screening for agronomically important traits in the genus are limited and attempts at wide hybridization between *Jatropha* and *Ricinus* met with limited success. Hence, the present investigation was undertaken to collect and characterize different species of *Jatropha* native to India and assess

the scope of their utilization in castor breeding programme and also the improvement of *Jatropha per se*.

Collection and Characterization

Jatropha species growing wild in non-arable lands or cultivated as ornamentals in horticultural gardens of the states of Andhra Pradesh and Tamil Nadu were collected and assembled in the species garden at the Directorate of Oilseeds Research. The plantings of four species, namely *J. curcas*, *J. gossypifolia*, *J. multifida* and *J. podagrica* were established through seeds, those of *J. integerrima* and *J. integerrima* var. *Rosea*, *J. tangorensis* from cuttings and *J. heterophylla* through tuberous root stock. The distinguishing and desirable characters of the species collected are presented in Table 1.

Detailed cytological and embryological studies were carried out to verify the chromosome number and assess the fertility status of the established plants.

Evaluation and Utilization

Jatropha species were evaluated for their reactions to biotic stresses and the results are summarized in Table 1. Under artificial inoculation conditions the species were found to be highly resistant to fusarial wilt caused by *Fusarium oxysporum* f. sp. *ricini*. Screening of the *Jatropha* species against major lepidopteran pests of castor viz., castor semilooper (*Achoea janata*), Red hairy caterpillar (*Amsacta albistriga*) and Bihar hairy caterpillar (*Spilosoma obliqua*) indicated varying levels of resistance with the species *J. integerrima* and *J. integerrima* var. *Rosea* conferring maximum resistance to the leaf eating caterpillars (Sujatha, 1996). Analysis of seed oil fatty acids showed the predominance of linoleic acid with a higher linoleic to oleic acid ratio in all species of *Jatropha* except *J. curcas* which was rich in oleic acid (Singh *et al.* 1996). Controlled pollinations between *Jatropha* and *Ricinus* in both direct and reciprocal directions indicated the existence of strong pre- and post-fertilization barriers to sexual hybridization. Histological and pollen-pistil interaction studies revealed the absence of active pollen-recognition-rejection phenomenon in the intergeneric crosses suggestive of strong incongruity (Sujatha, 1996).

Owing to strong barriers to crossability, tissue culture protocols have been standardized for various *Jatropha* species as a prelude to parasexual hybridization. The first successful attempt at whole plant regeneration from different explants of *J. integerrima* and *J. curcas* was reported (Sujatha and Dhingra 1993; Sujatha and Mukta 1996). While the regenerations of *J. curcas* expressed no phenotypic abnormalities, the regenerants of *J. integerrima* from hypocotyl explants resulted in somaclonal variants for flower colour and male sterility at frequencies of 16.7 and 8.3%, respectively. Phenotypic variants for flower colour lacked brown pigmentation on the leaves and produced light

Table 1. Species diversity in *Jatropha* found in India

<i>Jatropha</i> species	Place of occurrence	Chromosome No.	Fertility status	Distinct morphological features	Desirable attributes
<i>J. curcas</i> L.	Throughout the country	22	Fertile	Tree, highly branching, cordate-palmately lobed leaves, greenish-yellow flowers, distinct corymbose, tardily dehiscent fruits with black, large sized ecarunculate seeds	High oil content, drought resistant, frost tolerant, less attacked by insect pests, resistant to fusarial wilt.
<i>J. integerrima</i> Jacq. (<i>J. opanduraefolia</i> Andr., <i>J. acuminata</i> Desv., <i>J. hastata</i> Griseb. <i>Manihot diversifolia</i> Sweet)	Throughout the country	22	Fertile	Shrub, sparsely branched, ovate fiddle shaped leaves, crimson-red flowers, dehiscent capsules, seeds small carunculate brown with spots	Xerophytic adaptation, resistant to diseases and pests except leaf webber and scale, photoperiod insensitive
<i>J. integerrima</i> var <i>Rosea</i>	Throughout the country	22	Partially sterile	Shrub, freely branching, green ovate leaves with no brown pigmentation, light pink flowers	Ornamental, resistant to scale and <i>lepidopteran</i> insect pests
<i>J. glandulifera</i> Roxb. (<i>J. glauca</i> Vahl.)	S. India, Uttar Pradesh, Bengal	22	Fertile	Shrub, profuse branching, obovate leaves with glandular hairs on all vegetative parts, glandular corymbose cyme, greenish-yellow flowers, dehiscent capsules with small shining black carunculate seeds	Resistant to pests and diseases

(Cont. on next page)

<i>Jatropha</i> species	Place of occurrence	Chromosome No.	Fertility status	Distinct morphological features	Desirable attributes
<i>J. gossypifolia</i> L.	Throughout the country	22	Fertile	Shrub, profuse branching, cordate leaves, glandular plant parts, dark crimson-purple flowers, violently dehiscent capsules with small brown carunculate seeds	Resistant to scale, mites and leaf eating caterpillars, tolerant to salinity
<i>J. multifida</i> L.	Throughout the country	22	Fertile	Shrub/tree, uniform branching, leaves divided into 11 lobes, long petiole, long pedunculate flat topped cyme, coral red flowers, non dehiscent capsules with medium sized light brown earunculate seeds	Ornamental, photoperiod insensitive, non dehiscent capsules, resistant to fusarial wilt
<i>J. heterophylla</i> (J. heynii)	S. India	22	Fertile	Rhizomatous shrub, leaves ovate-cuneate, paniculate cyme, greenish-yellow flowers	Ephemeral
<i>J. podagrica</i> Hook.	Throughout the country	22	Fertile	Caudiciform shrub, cordate leaf with peltate base, flat topped corymbose cyme, bright scarlet flowers, violently dehiscent capsules with brown earunculate seeds	Ornamental and adapts well to xerophytic conditions, photoperiod insensitive, resistant to fusarial wilt.
<i>J. tanjorensis</i>	Coastal Tamil Nadu	22	Completely sterile	Shrub, profuse branching, cordate-palmately lobed leaves, margins distinctly serrate, greenish-yellow flowers with crimson red tinge, no fruit set	Used as live fence

pink coloured flowers unlike the parent with brownish-red leaves and crimson-red flowers.

Interspecific crosses among the different species of *Jatropha* in all possible combinations produced viable hybrids only in a few species crosses (Table 2). Barriers to interspecific crossability were weak in crosses involving *J. curcas* as the female parent and alternatively, with *J. integerrima* as the pollen parent. Reciprocal differences existed with regard to seed set and pollen germination. Histological examination of pollinated styles showed pollen germination ranging from 51 to 100%. Characterization of morphological and reproductive features of the interspecific hybrids revealed an interesting feature in the F_1 s of the cross between *J. curcas* x *J. integerrima*. While the hybrids expressed phenotypic intermediacy for various characteristics, the corolla color varied from dark pink through light pink to white. This distinct flower color variation has the scope of being utilized as a new ornamental plant since one of its parental species (*J. integerrima*) is widely known for its ornamental value. With the standardized protocol for rapid multiplication through *in vitro* techniques, these hybrids can be propagated easily.

Table 2. Cross-compatibility between different *Jatropha* species

	<i>J. curcas</i>	<i>J. gossypifolia</i>	<i>J. integerrima</i>	<i>J. integerrima</i> var. Rosea	<i>J. podagrica</i>	<i>J. multifida</i>
<i>J. curcas</i>	S	H	H	H	X	H
<i>J. gossypifolia</i>	H	S	X	X	X	X
<i>J. integerrima</i>	X	X	S	X	X	X
<i>J. integerrima</i> var. Rosea	X	X	X	*	X	X
<i>J. podagrica</i>	X	X	H	X	S	H
<i>J. multifida</i>	X	X	H	X	X	S
H-Successful	X-Unsuccessful		S-Selfed	*- No fruit set		

Interestingly, *J. integerrima* var. Rosea failed to set seed following selfing and crossing. Failure of fruit development in this species was established to be solely physiological. *J. tanjorensis*, a species found abundant in certain tracts of Tamil Nadu and grown as a fence plant due to its luxuriant growth habit showed intermediacy in phenotypic characters of *J. curcas* and *J. gossypifolia*. A detailed survey at its place of occurrence supplemented with cytological and biochemical evidences revealed this new species reported by the Botanic survey of India (Ellis and Saroja, 1961) to be a naturally occurring interspecific hybrid between *J. curcas* and *J. gossypifolia*. Abnormal meiotic divisions in the hybrids due to the parental genomic differences results in very poor male and female fertility leading to failure of fruit set.

In spite of strong reproductive isolation barriers between *Jatropha* and castor, *Jatropha* still has an important place in castor improvement since they possess many desirable attributes like pest and disease resistance which are lacking in the available castor germplasm. With the advent of modern biotechnological tools like somatic hybridization and genetic engineering, vast scope exists to transfer these desirable traits into castor. Since several species of *Jatropha* are cultivated for their ornamental flowers and a few for their potential as fuel substitute, any improvement in these species will have far reaching and positive implications.

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SCREENING WILD RICE SPECIES AGAINST BACTERIAL LEAF BLIGHT

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Key words : Wild rice species, bacterial blight

Breeding for resistance has been a major component of bacterial Leaf blight (BLB) management in recent years. Since the sources of high degree of resistance to this disease is very much limited in cultivated rice in India, search for alien genes from wild species has become a major attempt. Amante-Bordeos *et al.* (1992) have reported the transfer of BLB resistant gene from *Oryza minuta* to cultivated rice. Therefore, an attempt has been made to identify alternative sources of resistance from 52 different accessions of 3 wild species of rice viz. *O. nivara*, *O. rufipogon* and *O. spontanea* which are being maintained at our centre.

Plants were grown in 15" diameter earthen pots filled with 15 kg of well pulverised field soil fertilized with urea @ 125 kg N/ha. Two tillers of each of the species were removed from the original plants. The culture of *Xanthomonas campestris* pv. *oryzae*, used in the study was isolated from rice cv. Jaya procured from Hyderabad and the isolate was named as CRXCO 45. Single colony isolates were maintained on the plants of modified Wakimoto medium at 20°C. Fresh culture (48 h) of bacterial suspension made in sterile distilled water at a concentration of 10⁹ cells/ml was used for artificial inoculation. Fully developed top 3-4 leaves of 40 days old plants were inoculated by clipping method (Kauffman *et al.*, 1973). Observations were taken on the period of incubation for initial symptom expression and progress of the lesion at 4 days interval upto 25 days of the inoculation. Lesion length upto 2 cm was treated as resistance reaction.

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Disease symptoms appeared at 7, 8, 9 and 10 days after inoculation in different accessions of different species. In *O. nivara*, accession numbers 14497, 14504 and 14523 exhibited resistance reaction with incubation periods of 10 and 11 days and lesion length of 2.0, 0.5 and 1.9 cm respectively. The progress of lesion was very slow with necrotic lesion covering entire width of the leaf. In case of accession no. 14504 the incubation period was 11 days and the progress of lesion was also very slow and slightly pale brown in colour. All other accessions of *O. nivara* were found to be susceptible.

Table 1. Reaction of different accessions of wild species of *Oryza* against 5 different isolates of *Xanthomonas campestris* pv. *oryzae*

Sl. No.	<i>Oryza</i> species	Accession No.	Maximum lesion length in cm to 5 different isolates					Reaction
			CRXCO 7	CRXCO 11	CRXCO 37	CRXCO 49	CRXCO 52	
1.	<i>O. nivara</i>	14497	1.5	1.7	0.8	1.9	1.9	R
		14504	0.5	0.4	0.5	0.3	0.3	R
		14523	1.9	2.0	2.0	1.8	1.3	R
2.	<i>O. rufipogon</i>	14562	1.9	1.3	1.1	0.8	1.6	R
		14562	0.7	0.5	0.3	0.9	1.1	R

In case of *O. rufipogon*, accession no. 14562 and 14563 were found resistant with incubation period of 12 days. The disease symptoms appeared brown, covering full width of the leaf. The maximum lesion lengths were 2.0 and 1.3 respectively at the 25th day. Disease symptoms in other accessions of *O. rufipogon*, appeared after 8, 9 and 10 days of inoculation. The colour of lesion was brown and water soaked covering entire width of the leaf.

In *O. spontanea*, all the accessions showed susceptible reaction to BLB pathogen with incubation period of 8 and 9 days. Progress of lesion was from tip proceeding to mostly midrib and margins of leaves.

Resistant accessions of *O. nivara* and *O. rufipogon* were also tested with 5 virulent isolates (CRXCO 7, CRXCO 11, CRXCO 37 CRXCO 49 and CRXCO 52) collected from different parts of India, and accession nos. 14497, 14507 and 14523 of *O. nivara* and 14562 and 14563 of *O. rufipogon* were observed resistant to all the test isolates.

It is thus evident from the present study that wild rice can play vital role in transferring resistant gene(s) to cultivated rice through interspecific hybridization.

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Short Communication

NEW WHEAT GERMPLASM FROM INTERSPECIFIC CROSSES OF TRITICUM TIMOPHEEVI ZHUK. AND T. AESTIVUM LINN.

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A number of *timopheevi* derivatives, designated as Pusa *timopheevi* derivatives (PTD) developed from crosses of *T. timopheevi* with *T. aestivum* varieties and stocks have been found to be resistant against black, brown and yellow rusts. These new genetic sources were predominantly *aestivum* like in habit and other morphological characters.

A set of derivatives has been developed from interspecific crosses of *Triticum timopheevi* Zhuk and *T. aestivum* Linn. vars. and stocks (Bhowal *et al.*, 1990; 1991; 1993a) with the objective of transferring the genes for resistance to diseases, specially rusts from *T. timopheevi* to bread wheat varieties. These derivatives have been found to be resistant to black, brown and yellow rusts in multilocation tests (IRSN) conducted by Wheat Project Directorate. Seedling reaction tests against important virulent races of black, brown and yellow rusts have indicated the presence of genes, different from Sr36, Sr37 and Ir 18 already reported from *T. timopheevi* (Bhowal *et al.*, 1993 b). These derivatives have been designated as PTD (Pusa *timopheevi* derivatives) which form a set of new wheat germplasm. Morphological characterization of this new germplasm is reported in this short communication.

Twenty-two stabilised PTD lines (1, 2, 8, 11, 12, 16, 18, 28, 30, 32, 34, 40, 44, 47, 48, 49, 50, 61, 64, 65, 76, 83) were selected for this study (Table 1). Observations were recorded on growth habit, leaf, leaf hair, ear, glume, awn and kernel. The PTD lines along with two parental checks, Kalyansona and CM 108-31 (an induced semi-dwarf mutant of C 306) were grown in the field in single rows of 3m length with a spacing of 30 cm between rows and 10 cm between plants. *T. timopheevi* was not included in the field sowing as it requires photoperiodic treatment for flowering. It was grown in pots. Data on habit, leaf and hair character were recorded in mature green plants. Ear glume, awn and kernel characters were recorded after harvesting. Leaf hairs were observed under Nikon stereoscopic microscope model SMZ-10.

Table 1. Kernel characters of PTD lines

PTD No.	Kernel		Texture	Filling	Lusture
	Colour	Shape			
1	amber	longish ovate	med. hard	well-filled	-
2	"	ovate	"	"	-
8	red	longish ovate	hard	"	lustrous
11	amber	ovate	"	"	
12	"	"	"	filled	lustrous
16	"	"	"	"	dull
18	"	small ovate	"	little pitted	-
28	"	ovate	"	filled	dull
30	"	ovate	medium hard	little pitted	lustrous
32	"	longish ovate	hard	filled	"
34	"	ovate	medium hard	little pitted	"
40	"	ovate	hard	filled	"
44	red	longish ovate	"	little pitted	-
47	amber	small ovate	medium hard	"	-
48	red	"	hard	filled	dull
49	amber	narrow ovate	medium hard	little pitted	"
50	"	small ovate	hard	filled	-
61	amber	ovate	"	well filled	lustrous
64	amber	small ovate	med. hard	filled	dull
65	"	narrow ovate	med. hard	filled	lustrous
76	"	longish ovate	"	little pitted	dull
83	"	small ovate	"	filled	lustrous
Kalyansona	"	ovate	med. hard	"	-
CM108-31	"	ovate	hardm	well filled	lustrous
<i>T. timopheevi</i>	"	long ovate	"	filled	lustrous

T. timopheevi is characterized by having spreading winter-like habit, photo-sensitivity (very late flowering without extra photoperiod), profuse leaf and glume hair, adpressed ovate small ear. PTD lines had predominantly *aestivum* like leaves without profuse hairs, though a few derivatives had leafhairs intermediate between CM 108-31 and *T. timopheevi*. None of the PTD lines were as late as *Triticum timopheevi* or had adpressed small ovate ear unlike that of *timopheevi*. They had mostly long fusiform or oblong *aestivum*

Table 2. Morphological characters of PTD lines

Parents pedigree & Derivatives (PTD No.)	Habit Shape	Leaf Colour	Hair character	Glume hair	Glume colour	Ear type	Awn type	Awn colour
(CM 108-31 × timo) × KS ²								
1	Er	narrow	dark green auricle coloured	Dorsal longer upper hair, basal marginal upper hair, lower rare	nhr	w	Fusi	Fb w
2	Spr	"	dark green	Dorsal upper more, lower sparse, ventral upper sparse, lower rare	hr	br	Fusi	Fb bl
(CM 5B × timo) × CM 108-31								
8	Se	"	"	Dorsal upper and lower hair, ventral rare, basal marginal hair.	nhr	w	Fusi	Fb w
11	Er	necrotic broad green		Dorsal upper more, lower sarse, ventral rare, basal marginal hair.	hr	br	Fusi	Fb br
12	Se	broad	dark green	Dorsal upper more, lower rare, ventral upper more, lower rare, basal marginal	nhr	w	Ob	Fb w
16	Se	narrow	"	Dorsal and ventral rare	nhr	w	Fusi	Fb w
18	"	narrow dark green		Dorsal upper sparse, lower rare, ventral upper and lower rare	nhr	br	Fusi	Fb br

(Contd. on next page)

Parents pedigree & Derivatives (PTD No.)	Habit Shape	Leaf Colour	Hair character	Glume hair	Glume colour	Ear type	Awn type	Awn colour
(CM 108-31 $\times$ timo) $\times$ CM 108-31 ²								
28	Se broad	green	Dorsal and ventral upper sparse	nhr	w	Fusi	Fb	w
30	Er broad	dark green	Dorsal and ventral hair rare	nhr	w	Fusi lax	Fb	w
32	Er "	green	Dorsal lower upper sparse, marginal basal, more ventral hair.	hr	w	Fusi lax	Fb	w
34	Se necrotic broad	"	Dorsal rare, ventral upper and lower hair, no marginal hair	nhr	w	Fusi lax	Fb	w
40	Er narrow	dark green	Dorsal ventral hair rare	hr	w	Fusi	Fb	bl
(CM 108-31 $\times$ timo) $\times$ KS ³								
44	Er narrow	green	Dorsal upper lower sparse, ventral upper and lower rare, marginal hair	nhr	w	Fusi	Fb	w
47	Se narrow	dark green	Dorsal upper and lower hair, basal marginal ventral upper rare, lower no hair	nhr	br	Fusi	Fb	br
(CM 108-31 $\times$ timo) $\times$ KS ²								

(Contd. on next page)

Parents pedigree & Derivatives (PTD No.)	Habit	Shape	Leaf Colour	Hair character	Glume		Ear		Awn	
					hair	colour	type	colour	type	colour
48	Se	narrow	dark green	orsal upper more, lower sparse, ventral lower upper sparse, basal marginal hair	hr	br	Fusi	Fb	br	br
49	Se	narrow	"	Dorsal and ventral rare, basal marginal hair	nhr	w	Ob	Fb		w
50	Se	narrow	"	Dorsal upper sparse, lower rare, ventral rare, basal marginal hair	nhr	br	Fusi	Fb		br
61	Se	narrow	dark green auricle coloured	Fine upper dorsal hair, no lower hair, fine upper ventral hair, no marginal hair	hr	w	Fusi	Fb		W
64	"	narrow	dark green	Dorsal upper and lower hair, no marginal and ventral hair	nhr	br	Fusi	Fb		br
65	Se	narrow	"	Dorsal upper and lower hair rare, ventral very rare, basal marginal hair.	nhr	w	Fusi	Fb		w
76	Se	narrow	"	No dorsal and ventral hair	hr	br	Fusi	Fb		br
KS × (timo × KS) ³										

(Contd. on next page)

Parents pedigree & Derivatives (PTD No.)	Habit Shape	Leaf Colour	Hair character	Glume hair	Glume colour	Ear type	Awn type	Awn colour
83	Se narrow	"	Dorsal upper, sparse lower rare ventral non, ebasal marginal	nhr	w	Fusi	Fb	w
Kalyansona (En-k 58-nTh × N 10B) × Gabo 55	Se narrow	"	Dorsal tip rare, ventral tip still less, margin serated, no hair	nhr	br	Ob	Fb	br
CM 108-31 Induced Mutant of C 306	Se broad	"	Dorsal upper more lower rare, ventral upper sparse, margin serated, basal hair	hr	w	Ob	Fb	bl
N.I Vavilov Institute & plant Industry, Lenin grad. var. viticulosum								
<i>T. timopheevi</i>	Spr narrow	green	Ventral hair profuse large, marginal large hair, dorsal hair less profuse large	hr	w	Adpre ssed flat	Fb	w

Er : erect, Se : semi-erect, spr : spreading, hr : hairy, nh : non-hairy, w : white, br : brown, bl : black; Fusi : fusiform, Ob : oblong, Fb : full-bearded

type ear. Majority of PTD lines had non-hairy glume, only a few lines had glume hairs intermediate between CM 108-31 and *timopheevi*. *T. timopheevi* has characteristically long pitted kernels. PTD lines had mostly ovate, long ovate to small ovate kernels similar to *aestivum* type. While getting the PTD lines stabilised, selection pressure was applied for *aestivum* like plant type with semi-dwarf habit, early to medium early maturity, *aestivum* like long ear, good seed fertility, yield and resistance to stem, leaf and/or stripe rusts. So it is quite likely that the PTD lines will have predominantly *aestivum* like characters alongwith resistance to rusts.

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Short communication

GENETIC DIVERGENCE IN WHEAT

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Key words : Wheat, genetic divergence

Expression of heterosis largely depends upon the diversity of parents used in hybridization. Genetic divergence analysis provides an useful technique to identify such genetically variable strains representing diverse geographical regions. The experimental material was comprising of 23 exotic bread wheat lines selected from germplasm nurseries made available by NBPGR, New Delhi. These lines alongwith 13 exotic Indian wheat derivatives and a released cultivar, HD 2380, were grown at Regional Research Station, Bajaura (Kullu) in a randomized complete block design with three replications. Each entry was sown in three 3-meter long rows spaced 23 cm apart. Data were recorded on 10 randomly selected plants in each replication on various morphological and yield related traits were subjected to analysis of variance as well as multivariate analysis as suggested by Mahalanobis (1936). Clusters were formed as per method described by Tocher (Rao, 1952) and canonical analysis was done following Rao (1952).

Three genotypes were grouped into five clusters by application of clustering techniques. Cluster I had as many as twenty four genotypes representing diverse geographical regions. There were four genotypes in cluster II, one in cluster III, three in cluster IV and five in cluster V. The distribution of genotypes in different clusters was irrespective of their geographical proximity which is in confirmation with the finding of Reddy and Padmavathi (1996). They supposed that the diversity among genotypes belonging to same origin could be due to extremely variable environmental conditions which is desirable for selecting parents with similar adaptability. Inter-cluster D^2 values ranged from 233.90 (between clusters I and III) to 1043.36 (between clusters II and III), whereas not much differences existed for intra-cluster distances (Table 1).

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This indicates that the genotypes belonging to cluster II and III can exhibit maximum heterosis upon hybridization. The minimum distance between genotypes of clusters I and III revealed that the strains of these clusters are relatively closer, though they exhibited marked differences for days to 75 per cent flowering, plant height and grains/spike.

Table 1. Cluster composition and average inter- and intra-cluster (diagonal values) distances

Cluster	Stocks	Average distance				
		I	II	III	IV	V
I	EC-252503, -256488, 7DSN-51, -54, -82, -118, 2HEWSN-70, -153, 22IBWSN-149, 5HTSN-2, -21, WHT89-6, -8, -15, 16, -26, -27, -39, -223 PW-143*, -147*, 149*, BJW-280*, HD-2380**	132.65	689.43	233.90	713.10	417.65
II	PW-135*, -137*, -146*, BJW-279*		141.25	1043.36	873.81	687.33
III	BJW-283*			212.40	290.18	302.40
IV	2HEWSN-12, -47, -BJW-270*				170.08	390.11
V	7DSN-52, WHT89-25, PW-133*, BJW284*					210.00

* Indian * Exotic derivative

** Released cultivar

Table 2 shows that the strains of cluster II exhibited highest mean value for grain yield coupled with high harvest index and long peduncles. The genotypes belonging to different clusters with high mean values for yield components can thus help in obtaining wide spectrum of variability for these traits upon crossing.

Table 2. Cluster means for different characters in 37 wheat genetic stocks

Cluster	Days to 75% flowering	Days to maturity	Plant height (cm)	Peduncle length (cm)	Spike length (cm)	Grains per spike	Biological yield/plot (g)	Grain yield/plot (g)	Harvest Ind (%)
I	145.40	188.48	81.63	32.70	11.10	49.41	1560	400	20.40
II	140.00	185.67	90.67	48.04	7.92	43.17	1250	530	29.77
III	137.00	187.00	119.50	37.22	9.50	60.17	1530	450	22.72
IV	141.00	189.12	77.22	40.12	8.40	64.13	1470	390	18.50
V	135.88	184.20	65.18	34.28	10.78	56.30	1380	480	21.14

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INTERCEPTION OF DOWNY MILDEW (*PERONOSPORA* *MANSHURICA* (NAUMM.) SYD.) IN WILD SOYBEAN (*GLYCINE SOJA* SIEB. AND ZUCC.)

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Key words : Wild soybean, *Glycine soja*, downy mildew, *Peronospora manshurica*

Three hundred and four accessions of wild soybean strains (*Glycine* spp.) were received from USDA-ARS Urbana, Illinois in June, 1996 for quarantine clearance. On microscopic examination two accessions viz. PI-483464-B and PI-423999-A were found to carry dull milky white to pale-brown crust of oospores of downy mildew (*Peronospora manshurica* (Naum.) Syd.). Further information collected from GRIN (U.S.A.) revealed that PI-483464-B is a strain of *Glycine soja* Sieb. and Zucc. and was donated by Chinese Academy of Agricultural Sciences in 1984; PI 423999-A also belongs to *G. soja*, and was donated by N.I. Vavilov All Russian Scientific Research, Russian Federation, in 1976. Both the accessions are reported to be highly susceptible to Soybean Mosaic Virus (SMV).

Downy mildew of soybean which has a wide geographical distribution is not yet reported from India. However, it has been intercepted in soybean seed introductions from several countries (Mukewar *et al.*, 1980; Ram Nath *et al.* 1985; Agarwal *et al.* 1990 and Majumdar *et al.* 1991) including Malaysia and Indonesia where it is not reported as well (Agarwal and Khetrpal, 1985; and Anitha *et al.*, 1993).

Soybean seeds are known to play a vital role in the dissemination of this dreaded pathogen (Richardson, 1990). The present interception emphasizes the need for utmost care and vigilance while processing soybean germplasm for quarantine clearance in view of the destructive nature of the pathogen, existence of a large number of physiological races (Dunleavy, 1977; Lim *et al.*, 1984; and marcinkowska, 1987) and zero tolerance prescribed for quarantine purposes (Neergaard, 1977).

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Short communication

**DOWNY MILDEW OF SOYBEAN (*GLYCINE MAX* (L.)
MERR.) — A DREADED SEED TRANSMITTED DISEASE
HITHERTO NOT REPORTED FROM INDIA**

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Key words: Soybean, *Glycine max*, Downy mildew, *Peronospora manshurica*,
Seed transmission

Soybean, *Glycine max* (L.) Merrill having both protein and oil, is an important source of low-cost food. Its oil is at top ranking position in the world oil production. Soybean is grown to greater or lesser extent in most parts of the world and occupies more than 62 million h area under cultivation. The total production of soybean in the world is more than 136 million m ton (FAO, 1995). The importance of soybean in India has become overwhelming in view of the shortage of edible oils in the country. In late seventies, the Government of India decided to import soybean seed on large scale for sowing purposes to boost up oil production in the country. At present there is a large area under soybean cultivation in India, particularly in Bihar, Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh. During 1994, the total area under cultivation in India was 3.95 million h and total production was 3.3 m tons (FAO, 1995). Cultivation of soybean to the required extent has not taken place though it has augmented edible oil resource of India by about 0.6 million tons per year, contributing to the foreign exchange to the extent of US \$ 500 million per year (Ali, 1996).

Seed is the most important source of survival and long distance dissemination of plant pathogens and therefore, there is always a risk of introducing exotic pests and pathogens alongwith seed imports. Some of the major plant pathogens reported to be seed-borne in soybean are : *Alternaria tenuissima*, *Arkoala nigra* (Black leaf blight), *Ascochyta sojicola* (leaf spot), *Aspergillus quercinus*, *Botrytis cinerea*, *Cercospora kikuchii* (purple blotch, purple seed stain), *C. sojina* (frog eye leaf spot), *Colletotrichum dematium*, *C. truncatum* (seedling blight, anthracnose), *Colletotrichum* spp., *Corynespora cassiicola* (target spot), *Diaporthe phaseolorum* var. *batatatis* (stem canker, pod and stem blight), *D. phaseolorum* var. *caulivora*, *D. phaseolorum* var. *sojae* (pod and stem blight),

Fusarium spp. (Fusarium wilt), *Glomerella cingulata* (anthracnose), *Macrophomina mame*, *M. phaseolina* (charcol rot), *Melanopsichium nepalense*, *Peronospora manshurica* (downy mildew), *Phialophora gregata* (Brown stem rot), *Phytophthora megasperma* var. *sojae* (root and stem rot) and *Pleosphaerulina sojicola* (Phyllosticta leaf spot), *Rhizoctonia leguminicola* (black patch), *R. solani* (Damping off, foot and basal stem rot), *Sclerotinia sclerotiorum* (Sclerotinia stem rot), *Sclerotium* sp., *Septoria glycine* (brown spot), *Thilavia basicola*, *Bacillus subtilis*, *Corynebacterium* sp. (Seedling wilt, stunt), *Curtobacterium flaccumfaciens* (wilt) *Pseudomonas solanacearum* (wilt), *Pseudomonas syringae* pv. *glycinea* (Bacterial blight), *P. s.* pv. *tabaci* (Wild fire), *Xanthomonas campestris* pv. *glycines* (Bacterial pustule), Arabis mosaic virus, Bean pod mottle virus, Cacao necrosis virus, Cherry leaf roll virus, Cowpea mild mottle virus, Cucumber mosaic virus, Grapevine fan leaf virus, Mulberry ring spot virus, Raspberry ring spot virus, Soybean mild mosaic virus, Soybean mosaic virus, Soybean stunt mottle virus, Tobacco ring spot virus, Tobacco streak virus, Tomato black ring virus and Tomato ring spot virus (Richardson, 1990). Among these, *P. manshurica* (downy mildew) is of highest quarantine significance for India as the disease does not occur in the country and also due to destructive nature of the pathogen, and its existing races.

Geographical distribution

The disease was first reported from United States in 1923 (Sinclair, 1982) and is now occurring in Argentina, Australia, Brazil, Bulgaria, Burmuda, Canada, China, Colombia, Czechoslovakia, Denmark, England, France, Hungary, Iran, Isreal, Italy, Japan, Kora, Mexico, New Zealand, Nigeria, Philippines, Poland, Rhodesia, Romania, South Africa, Sweden, Taiwan, Thailand, Turkey, U.S.A., U.S.S.R. and Yugoslavia (CMI, 1979; Roongruangsree *et al.*, 1988; Kingsley, 1960).

Pathogen

The hyphae of *P. manshurica*, are intercellular in host tissues, coenocytic, and 7-10 μ m wide. Sporangioophores are slender (240-984 $\times$ 5-9 μ m) and tree like, with erect "trunks" grey to pale violet, emerging singly or in clusters from stomata on lower surface of leaf and 2 to 10 times dichotomously branched. The terminal branchlets or sterigmata (9-13 $\times$ 2-3 μ m) are pointed and more or less straight. Sporangia (usually 19-24 μ m) are subglobose without an apical papilla and germinate in water from an indeterminate point on the side. The antheridia fertilize oogonia leading to the development of light brown or yellow oospores with smooth or variously marked outerwall. The oospores become visible in mounts stained with cotton blue. Oospores are 30-50 μ m with an outer wall which is pale yellow and evenly ridged. Oospores

develop on the seed surface and appear as milky white crust consisting of a mass of the hyaline spherical resting spores.

P. manshurica reduced yield by 45% in Bulgaria (Nedelchev, 1978).

Detection of oospores

Johnson and Lefebvre (1942) were the first to detect crusts of oospores of *P. manshurica* on soybean seeds and indicated that the disease was seed-borne. Seed transmission was established by Jones and Torrie (1946). Pathak *et al.*, (1978) detected *P. manshurica* on seeds of soybean by dry seed examination and washing test and also described the tetrazolium test for spore viability. *Peronospora manshurica* forms encrustations of mycelium and oospores on seeds, which then appear milky white (Pietkiewiez, 1959). Infected seeds may be smaller and lighter in weight than the normal ones. Mycelium is found primarily in cell layers in seed coat. Infected seeds may not germinate or may produce systematically infected seedlings (Poonpolgul and Pupipat, 1978; Rosca, 1975; Inaba *et al.*, 1982; Zad, 1989). Marcinkowska (1987) reported that the oospore-encrusted seeds serve as source of primary infection and seedling emergence may be delayed by 2 weeks in the infected seeds. Ovchinnikova and Potlaichuk (1980) developed an indirect oospore detection technique by placing seeds into hollows of sterilized ceramic tiles filled with sterilized water, then covered with glass and incubated at 24- 26°C and reported the development of *P. manshurica* symptoms on seeds after 4 days. Roongruangsree *et al.*, (1988) also developed a Fuelgen technique for detection of mycelium and oospore crust on seed.

Quarantine interception

Soybean downy mildew has not yet been reported from India. However, it was detected (intercepted) on seeds of soybean imported from different countries (Mukewar, *et al.*, 1980; Ram Nath *et al.*, 1981, Agarwal *et al.*, 1990, Majumdar *et al.*, 1991, Agarwal *et al.*, 1996). It has also been intercepted on seeds imported from Malaysia and Indonesia where it is not yet reported (Agarwal and Khetarpal, 1985, Anitha *et al.*, 1993). Butler (1918) reported that *P. trifoliorum* de Bary causing downy mildew in wild species of lucerne and barseem, also attacks soybean (*Glycine hispida* Maxim.) in Kashmir. He reported that *P. trifoliorum* attacking *G. hispida* agreed in its general characters with *P. viciae* on peas; the oospores measuring 24-31 µm in diameter with a thick smooth light brown wall. He further emphasized that a variety of the fungus i.e. *P. trifoliorum* var. *manshurica* Naum. described on soybean from Russian *manshurica* differed greatly from *P. trifoliorum* on *G. hispida*, in having longer conidiophores, nearly round conidia and longer oospores (36-45 µm in diameter). Observations of Butler (1918), and upto date literature survey do not suggest

the occurrence of downy mildew of soybean in India. Hence a constant vigil against the introduction of such dreaded disease through the imported material is of utmost importance. Pathak *et al.* (1978) detected oospores on seed samples from 17 countries and Roongruangsree *et al.* (1988) on seed samples from 5 countries. Rosca (1976) intercepted *P. manshurica* from Romania. Agarwal and Singh (1996) reported from India that while processing of 10,336 samples during 1978-1995 downy mildew (*P. manshurica*) was intercepted in 1514 samples from 15 countries.

Physiological races

Thirty three physiologic races of *P. manshurica* have been reported from U.S.A. alone by Dunleavy (1977) and Lim *et al.* (1984). Morcinkowska (1987) reported 11 physiologic races in Poland and later, on characterization he added 7 races (34-40) for the first time (Marcinkowska, 1991). Li *et al.* (1992) collected samples from 9 different countries and identified 3 new races of *P. manshurica* and designated as Zhong 1, 2 and 3. Two soybean cultivars viz., Kanrich and Mendota are resistant to all races in U.S.A. This resistance to all downy mildew fungus is controlled by a single gene Rpm (Lim *et al.*, 1984).

Viability of oospores

The oospores of *P. manshurica* could retain viability from 1 to 8 years (Kovetskii, 1970; Naumova and Obtemperanskaya, 1988; Pathak *et al.*, 1978). Roongruangsree *et al.*, (1988) reported that portions of the mycelium of *P. manshurica* may survive even on the surface of dry, mature seeds.

Dunleavy and Snyder (1962) developed a germination technique for the viability test of oospore and reported 12.6-29.8% germination. The International Seed Testing Association (ISTA, 1976) recommended the use of 2, 3, 5-triphenyl tetrazolium chloride for determining the viability of oospores after 1 year of storage. Pathak *et al.* (1978) reported 30-39% viability in 1-2 year old and 20% in 8 year old oospores by tetrazolium test. They also reported 6-11% viability in oospores collected from 1 year old captan treated seeds. Roongruangsree *et al.* (1988) reported Phloxin B as a promising stain for determination of oospore viability.

Control

Seed is the important source of long distance dissemination and survival of the pathogen. Hence during exchange of seed material, there is always a risk of introduction of the pathogen into new areas where it is not known to occur. Several workers have reported the effective control of the disease by spraying the crop in field as well as by seed treatment. Fundazol, Ridomil, Previcur S 70, Apron 35 SD (Metalaxyl) and Sandofan M (Oxadixyl + mancozeb)

have been reported to be the effective fungicides in controlling the downy mildew disease in soybean (Anonymous, 1978; Dragoescu *et al.*, 1979; Zaggerini *et al.*, 1986) under field conditions. However, methods developed so far are not good enough to eliminate the pathogen from seed. Research aspects on various means of complete elimination of the pathogen from seed (both oospores on the seed and mycelium in the seed) has to be undertaken to eradicate the pathogen by salvaging the infected/contaminated material and making the disease free seed available to the users/breeders for utilization in crop improvement programmes.

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EVALUATION OF EXOTIC GERMPLASM LINES OF SESAME

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Key words : Sesame, *Sesamum indicum* L., germplasm

Sesame (*Sesamum indicum* L.) is an important and ancient oil crop cultivated extensively from tropical to temperate zones in the world. Asia accounts for 2/3rd of the sesame global production. India, China and Republic of Korea are the major producers, though the crop is grown in several other countries also. India, with an area of 2.03 m ha under this crop, is a major producer accounting for 38 per cent of the world's sesame area and 25 per cent of its production (0.62 m. tonnes). However, the average per hectare yield is rather low (304 kg/ha) compared to other sesame growing countries of the world. One of the reasons for low productivity must be lack of high yielding varieties having wider adaptability. Most of the released varieties are the selections from local landraces and hence adapted only to the environments from which they were derived. Introductions and introgression of desirable genes from diverse germplasm sources is very essential for any improvement in the present yield level. With this in view, collection, evaluation and utilization of diverse germplasm have been initiated at Directorate of Oilseeds Research, Hyderabad and the diversity of some of the exotic collections is presented in this paper.

Eighty exotic accessions of sesame received from NBPGR Regional Station, Akola, were evaluated for seed yield and other characters. The material was raised during summer 1996 in single row of four metre length, spaced at 45 cm between the rows and 15 cm within plants, using an augmented randomised block design, with five cultivated varieties (Rajeswari, CO 1, JLT 26, Phule till 1 and TC 25) as checks replicated four times. Observations were recorded on five randomly selected plants in each accession for plant height, number of branches, number of capsules per plant, days to 50% flowering, seed yield per plant and oil content. The mean values were taken for statistical analysis

and the index score method of Anderson (1957) was used to analyse the variation pattern.

The plant height of germplasm lines ranged from 73.36 to 123.04 cm with the mean of 97.38 cm. Out of 80 germplasm lines, 25 were tall, 46 medium and 9 dwarf (Table 1). The mean number of branches per plant ranged from 2.30 to 12.23. The number of capsules per plant ranged from 27.89 to 297.04 with the mean of 72.49. Majority of the lines (56) had intermediate values (51 to 100) and ten lines recorded more than 100 capsules per plant. Variability for days to flowering was very low with a range of 28.60 to 35.60 days.

Table 1. Score index for morphological characters in sesame

Character	Range	Values at different indices		
		Low	medium	High
Plant height (cm)	73.36 - 123.04	100 (25)	80 - 100 (46)	80 (9)
No. of branches/plant	2.30 - 12.23	4 (15)	4 - 8 (60)	8 (5)
No. of capsules/plant	27.89 - 297.04	50 (14)	50 - 100 (56)	100 (10)
Days to flowering	28.60 - 35.60	35 (5)	30 - 35 (66)	30 (9)
Seed yield/plant (g)	3.90 - 19.94	5 (4)	5 - 10 (56)	10 (20)
Oil content (%)	42.00 - 53.33	45 (6)	45 - 50 (59)	50 (15)

Values in parenthesis indicate the number of accessions in that group.

Seed yield per plant ranged from 3.90 to 19.94 g, the maximum being recorded by EC - 303311. Twenty lines showed more than 10 g of seed yield per plant. Oil contents ranged from 42.00 to 53.33 per cent with 15 lines having more than 50 per cent of oil. These lines were also screened for resistance to major pests and diseases under field conditions. Because of dry weather conditions and high temperatures during the crop growth, the pest incidence was very low.

Based on the index score values, 20 promising lines were selected (Table 2) which could be utilized in the hybridization programme to develop high yielding varieties and hybrids.

Table 2. Performance of promising exotic collections of sesame

	Accession number	Plant height (cm)	No. of branches/ plant	No. of capsules/ plant	Days to flowering	Seed yield/ plant (g)	Oil content (%)
1.	EC - 303311	122.64	5.30	134.91	31.40	19.94	51.98
2.	EC - 303437	108.24	8.10	112.51	31.40	18.96	45.85
3.	EC - 303434	103.04	7.30	88.31	32.40	16.98	44.99
4.	EC - 303429	112.84	6.50	113.71	32.40	15.76	46.28
5.	EC - 303433	118.04	4.50	93.11	30.40	13.78	42.79
6.	EC - 303432	104.24	6.30	104.91	29.40	13.50	46.25
7.	EC - 303440	119.24	5.50	113.91	31.40	13.24	46.73
8.	EC - 303304	109.04	3.50	103.31	32.40	13.20	50.82
9.	EC - 303418	123.04	5.70	112.31	31.40	12.74	44.35
10.	EC - 303306	100.04	3.90	84.21	31.40	12.64	52.37
11.	EC - 52095/10	110.44	3.90	84.51	30.40	12.34	49.63
12.	EC - 334994	103.76	5.30	84.09	33.60	11.84	45.05
13.	EC - 310437	82.04	3.50	75.31	30.04	11.68	53.33
14.	EC - 335001	93.56	4.10	66.89	31.60	11.24	46.30
15.	EC - 331884	105.96	5.30	83.69	30.60	10.72	50.02
16.	EC - 15042	114.04	12.23	297.04	31.40	10.64	48.54
17.	EC - 335008	93.46	3.85	74.04	32.60	10.56	46.19
18.	EC - 310454	104.04	3.90	73.11	30.40	10.54	52.27
19.	EC - 310455	93.04	2.30	60.71	29.40	10.12	46.23
20.	EC - 303436	110.79	5.90	86.21	30.40	10.06	45.23
	C.V (%)	3.41	14.43	12.09	1.92	10.58	2.62

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INFLUENCE OF TEMPERATURES AND CONTAINERS ON THE STORAGE OF CHILLI SEEDS

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Key words : Temperature, containers, storage, chilli, seeds

Chilli (*Capsicum annuum* L) is an important commercial vegetable crop cultivated for tender green and red ripe fruits all over India. Being a native of South America, the species is well adapted to Indian climate conditions and exhibits a greater variation for several economical plant characters. The variation is of great importance for evolving suitable genotypes having high productivity, good fruit quality and resistance to several biotic and abiotic stresses. Of late large scale commercialization of farming resulted in replacement of old cultivars with high yielding ones and improper storage conditions poses a serious threat to gene pool. In order to arrest the process of genetic erosion, seeds are to be preserved in suitable conditions. A limited information is available in this crop. Seeds are popular media for the germplasm conservation. Several internal and external factors contribute to seed deterioration. High temperature and moisture during storage enhance the process of deterioration (Bass, 1980). Further, yield is affected by growing plants from older seeds (Frohlich and Henkel, 1964). The present experiment was conducted with the view to study storability behaviour in chilli seeds and suggests suitable remedy for longer retention of high viability and vigour.

Seeds of chilli cv Arka Lohit were extracted from red ripe fruits and dried in shade. Seed moisture content, estimated by oven method, was found to be 7.5 per cent. Seeds were packed in kraft paper, glass, polyethylene bags (250 gauge) and laminated aluminium foil pouches and stored for 5 years at ambient (16-35°C), low (5°C) and sub-zero (-20°C) temperatures. Seed viability and vigour were assessed in stored seeds at regular intervals. Seed viability was expressed in terms of percentage of germination. One hundred seeds in each replication in 3 replication were germinated on top of paper method at an alternate temperature of 20-30°C for 16 and 8 hours respectively in seed germinator. Seedlings were evaluated as per the standard ISTA procedure (Anon., 1985). Seedling vigour was compared by means of coefficient of

germination, root length, shoot length, dry weight and vigour indices. Shoot and root length were recorded on 8 days old seedlings. Seedlings were dried in oven at 60°C for 48 hours and dry weight was recorded. Mathematically seed vigour was calculated by using germination speed and expressed as sum of days taken for germination. Vigour indices I and II were calculated by multiplying percentage of germination with seedling length and dry weight respectively.

Seed viability and storability were significantly affected by the storage temperatures and packaging materials (Table 1). Seeds were short lived for 3 years under ambient temperatures and the highest percentage of germination was recorded in seeds stored in paper bags followed by polyethylene bags. It appears that seed moisture of 7.5% is not congenial especially for sealed storage as evidenced by significant reduction of germination in glass and laminated aluminium foil pouches stored seeds. None of the seed from all containers were germinable during 4th year of storage.

Table 1. Seed germination during storage of chilli seeds

Storage Temp (°C)	Storage Containers	Storage period (years)				
		1	2	3	4	5
Ambient	K paper	91	83	78	0	0
	Glass	85	37	29	0	0
	Polyethylene	91	82	58	0	0
	Al foil	87	31	4	0	0
5	K paper	96	91	91	94	85
	Glass	97	95	94	91	92
	Polyethylene	94	93	95	93	93
	Al foil	93	97	95	97	92
-20	K paper	16	9	0	0	0
	Glass	93	95	95	91	90
	Polyethylene	93	96	97	93	93
	Al foil	93	97	95	97	97

C D at 5% 8.6

Seed viability was preserved for 5 years at low and sub-zero temperatures. At 5°C, the initial germination was retained for 5 years in all the containers except paper bags. Likewise, seed viability is lost rapidly when stored in paper bags at -20°C after 1 year of storage. Polyethylene and aluminium foil laminated pouches are effective in retaining the initial viability for 5 years

even at given moisture level. The percentage of germination was 97 in seeds stored in aluminium foil laminated pouches, 93 in polyethylene bags and 90 in glass containers at -20°C after 5 years of storage.

The seedling growth was slightly affected by the storage containers and temperatures. However, shoot and root length were higher for seeds stored in aluminium foil laminated pouches (Table 2). There was no significant difference observed for dry weight amongst the packaging material used.

Table 2. Seedling characters as influenced by temperatures and packaging during 5 th year of storage

Storage Temp. $^{\circ}\text{C}$	Storage Containers	Coeff. of germination	Shoot length (cm)	Root length (cm)	Dry wt (mg)
5	K paper	15.2	2.2	5.3	2.8
	Glass	15.8	2.4	5.0	2.8
	Polyethylene	15.5	2.1	4.9	2.5
	Al foil	15.4	2.8	6.4	2.8
-20	K paper	-	-	-	-
	Glass	15.5	2.4	4.8	2.6
	Polyethylene	17.4	2.5	4.5	2.8
	Al foil	16.4	2.2	5.1	3.0
C D at 5%		0.99	NS	0.86	NS

Table 3. Influence of temperature and packaging on seedling vigour during 5 th year of storage

Storage Temp. $^{\circ}\text{C}$	Storage Containers	Vigour	Vigour index-I	Vigour index-II
5	K paper	13.1	635	233
	Glass	14.8	684	258
	Polyethylene	14.7	653	236
	Al foil	14.5	840	255
-20	K paper	-	-	-
	Glass	13.4	650	238
	Polyethylene	16.6	653	258
	Al foil	16.3	706	294
C D at 5%		0.81	117	35

Seed vigour was successfully retained for 5 years at low temperature storage (Table 3). It was relatively higher for seeds stored in aluminium foil pouches both at 5°C and -20°C storage.

Chilli seeds appear to be poor storer under ambient conditions as observed by drastic reduction of viability during second years of ambient storage. It was particularly higher in sealed storage than unsealed storage. This might be due to moisture content in seeds. This was affected only at ambient temperature and not at 5°C or -20°C. Prevalence of high temperature in presence of high seed moisture enhances the process of deterioration resulting in low percentage of germination and vigour (Harrington, 1973). High seed moisture is more harmful when stored in small enclosure than larger ones as the exchange of moisture vapour is restricted (James, 1967). The loss of viability was slower at cooler temperatures (Harrington, 1972). In low temperature storage the period of seed longevity varied depending upon the containers used for storage. The percentage of germination was higher for seeds stored in aluminium foil laminated pouches followed by polyethylene bags. However, seeds stored in paper bags at -20°C fails to maintain the viability owing to freezing injury resulting death of seeds. Thus paper containers are not suitable for seed storage at sub-zero temperature. The choice of packaging material depends on storage conditions (Popovska *et al.* 1981). Polyethylene bags are effective, readily available and inexpensive packaging for seed storage at 5°C. While aluminium foil laminated pouches are suitable for preserving valuable seeds at -20°C for longer period. Chilli seeds are poor storer and need special packaging and low temperature for retaining high viability and vigour for longer period, which could be utilized for conservation of germplasm.

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ANNOUNCEMENT

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

REGISTRATION OF PLANT GERMPLASM

Need for registration of plant germplasm has been under the consideration of the Indian Council of Agricultural Research for sometime. Due recognition is accorded to scientists who develop improved cultivars as per the release procedure available for the purpose. Unlike the developers of released cultivars, scientists associated with the development of improved germplasm and genetic stocks (new resources of resistance, male sterility, varied types of mutants, cytogenetic stocks etc.) have no mechanism for recognition. Lack of formal recognition of such useful materials and the role of scientist in development of these materials, discourages them from sharing the valuable materials with other workers. Consequently, most of such valuable material remains under utilized or get lost. With the recent developments concerning IPR and other related issues, due recognition of these materials has become all the more important.

Keeping these considerations in view, the Council constituted a Committee to suggest guidelines for identification and registration of value-added germplasm. The recommendations of the Committee have been approved by the Council for implementation. National Bureau of Plant Genetic Resources (NBPGR) has been identified as the nodal agency for implementation. The enclosed Annexures I, II & III specify the procedure for identification and registration of germplasm of crop plants. It is hoped that this registration will encourage better sharing of genetic materials among the scientists.

Chief Editor's View

Editorial committee regrets the slight delay in the publication of the current issue of Indian Journal of Plant Genetic Resources (IJPGR). This issue was due in July but is being released in September 1997. The main reason being the extremely busy schedule of editorial board members and Chief editor during all these months. However, we are happy to release this issue as our tribute to the Nation's 50th year of Independence. This issue will be released on September 12, 1997 and will be distributed to more than 120 PGR scientists participating in a three day Consultation-cum-Training Workshop on Conservation, Utilization and Registration of Plant Genetic Resources (PGR) on Agro-biodiversity being held at NBPGR from 10-12 September 1997.

In the last issue of IJPGR, the PGR scientists were advised to improve upon the content and quality of their contributions submitted for publication in IJPGR. With the increasing number of papers being received, we will be able to accomodate only the articles of direct relevance to PGR. The source and origin of the germplasm material used for the study should be clearly mentioned. To promote the utilisation, the study, identifying superior germplasm must clearly indicate about the important character(s) they possess and availability of seed/vegetative material their of. The freshly harvested seed of the same should be made available for their long term conservation in the National Gene Bank. The mechanism of registration of thoroughly studied and well documented germplasm/genetic stock possessing specific desirable attribute(s) is now available. The present issue of IJPGR has published the guidelines for the registration of germplasm/genetic stock as adopted by the Indian Council of Agricultural Research (ICAR).

Editor-in-Chief

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